Vol. 54, No. 2 March, 1947

Psychological Review

EDITED BY
HERBERT S. LANGFELD
PRINCETON UNIVERSITY

CONTENTS

Charles Hubbard Judd: 1873–1946: FRANK N. FREEMAN 59

Perceptual Abstraction and Art: RUDOLF ARNHEIM 66

A Theoretical Derivation of Latent Learning: JOHN P. SEWARD 83

Consciousness as Organismic Physiological Functioning: WILLIAM W. MARTIN 99

PUBLISHED BI-MONTHLY BY THE
AMERICAN PSYCHOLOGICAL ASSOCIATION, INC.
PRINCE AND LEMON STS., LANCASTER, PA.
AND 1515 MASSACHUSETTS AVE., N. W., WASHINGTON 5, D. C.

Entered as second-class matter July 13, 1897, at the post-office at Lancaster, Pa., under Act of Congress of March 3, 1879

Charles H. Judd.

VOL. 54, NO. 2 MARCH, 1947

THE PSYCHOLOGICAL REVIEW

CHARLES HUBBARD JUDD

1873–1946

Charles H. Judd died on July 18, 1946, at his home at Santa Barbara, California, at the age of 73. He had carried on his usual high pitch of activity following his retirement from his duties at the University of Chicago eight years previously. It seemed likely that he would continue to be productive for many more years when he was laid low by a malignant tumor of the pancreas which defied remedy by the best surgical skill. He journeyed to Milwaukee in March in much pain to give the annual address at the meeting of Kappa Delta Pi, the educational fraternity, and went to the hospital in Chicago immediately thereafter. He never recovered from the operation. Thus ended a career which was equally distinguished in psychology and in education.

Judd's career naturally divides itself into two periods, the first culminating in his appointment as Professor of Psychology and Director of the Psychological Laboratory at Yale University, and the second covering his tenure at the University of Chicago as head of the School of Education. It might be said without exaggeration that he had two careers, the one in psychology and the other in education. Certainly he accomplished enough during his lifetime to match the lifetime accomplishment of more than two ordinary university men. He did a very considerable amount of research and directed a great deal more; he wrote voluminously on a variety of subjects, including technical articles and monographs, textbooks at the college and school level, reports, essays and addresses; he carried a heavy load of administrative responsibility throughout most of his academic life; he participated in professional organizations of many kinds, and exerted a deep influence on them; and in addition to all this he carried a full load of teaching throughout his entire length of service.

After having thoroughly established himself in the field of general psychology, Judd took a leading part in the development of the field of educational psychology. He did a large part of the spade work in laying the foundation of this field by research, particularly of the laboratory type, and he built on this foundation a large structure of applications and educational theory. He was one of the chief agents in the advancement of educational psychology from a subject which, in William James' phrase, was worth about six weeks treatment, to a whole galaxy of subjects occupying several major divisions.

Judd's contribution to educational organization, practice and theory, at all levels, was as conspicuous as to his special field. He had a strong influence on curriculum and methods in the elementary school and the high school, on the organization of school units, particularly the junior high school and the

junior college, and on the national policy and program in education. He had a large part in the choice of men for high positions in the nation and in the policies they pursued once they were chosen.

How much of Judd's attainment was due to his inherited characteristics and how much to his education and training it is of course impossible to say. That his extraordinary energy, force and keenness of mind may be attributed largely to endowment seems highly probable. On the other hand, his intense seriousness of purpose, devotion to duty, sense of responsibility and uncompromising honesty may have been engendered by his early upbringing. His father was a Methodist missionary in India, and he in turn evidently belonged to a devout Methodist family, since he was named Charles Wesley. The boy was brought to this country at the age of six on account of the poor health of his parents, both of whom died within five years. After being orphaned he was brought up on meager resources by an older sister.

Upon graduation from high school in Binghamton, New York, at the age of seventeen, Judd entered Wesleyan University, where his sister had taken up her residence in order to provide him a home. He relates in his autobiographical sketch in the *History of Psychology in Autobiography*, Vol. II, 1932, that he had been doing poor work in high school when he was called in by the pastor of the Methodist church, who took a deep interest in him and later lent him the money to support him in Germany. His pastoral adviser told him the teachers believed that he lacked the ability to succeed in high school work. From the perspective of his subsequent achievements this looks like a conspiracy. In any case it served to stimulate the youth to greater application to his studies and from then on his progress astonished both himself and his teachers. His exceptional attainment continued through college, where according to the common report ten years later he had taken more prizes than any other student in the history of the institution. I myself heard him relate that he proposed to try for special honors in two subjects, classics and philosophy, including psychology. His philosophy professor, Armstrong, agreed to this proposal, but Merrill, the professor of classics, would not tolerate divided allegiance. He thereupon chose philosophy and psychology, and thus determined the course of his future career. His college life, however, was not all grind. He joined a fraternity and attained the highest honor at the hands of his fellow students, the managership of the football team. (His successor, the following year, was E. L. Thorndike. The two men also studied the psychology of William James together in an advanced course in psychology.) Be it noted that his interest in physical exercise was largely vicarious.

During his college career, Judd's interest shifted from the ministry to specialization in science, particularly psychology. He was influenced by such men as Rosa in physics and Conn in biology, as well as by his major professor, Armstrong. The faculty at Wesleyan was remarkable for its distinction and for its influence in stimulating students to go on for advanced work. Judd developed a strong interest in the scientific approach to the study of mankind and was strongly impressed by the conception of evolution as expounded by such men as Herbert Spencer. Two of the professors of science, Conn and Rice, attempted to reconcile science and theology along the line of the better known effort of Andrew D. White, but Judd came to regard the scientific treatment of experience as a complete and self-sufficient method. He devoted himself

to it with all the enthusiasm of a convert, and pursued it, not merely as a profession, but as the key to the solution of the problems of human life.

When Judd was graduated from college in 1894 the first generation of American students who had gone to Germany to take their Ph.D.s had returned and established departments of psychology in this country. Hall had taught at Hopkins and then become president of Clark. Cattell was at Columbia and Titchener at Cornell. James was a leading figure at Harvard and Ladd at Yale. However, many of the young men who planned to specialize in psychology still looked to Wundt's laboratory as the one that offered the greatest opportunity for advanced work. Wundt's prestige overshadowed that of all others in the experimental field, even though he had relinquished a large part of the active direction of his laboratory to Meumann. These considerations, coupled with Armstrong's advice, doubtless led Judd to go to Leipzig for his graduate work.

Since he was living on borrowed money and since he suffered from loneliness throughout his sojourn in the foreign land, the young student of twenty-one had little time or inclination for anything but application to his work, in order that he might return to his homeland at the earliest possible moment. He therefore completed all the requirements for the degree by the middle of the second year and had the spring left over to devote to the translation of Wundt's *Grundriss*. The fact that Wundt broke his rule to permit the translation of this volume into English indicates that he must have had a high regard for his young American student.

Judd has himself acknowledged his high indebtedness to Wundt, not only for the direction of his graduate work, but still more for the contribution Wundt made to the development of his psychological conceptions and points of view. He was also influenced profoundly by James, both by his biological approach to the problems of psychology and by his pragmatic philosophy. He comments regretfully on the conflicts and perhaps jealousy that existed between these two masters, but did not let this interfere with his paying allegiance to both of them.

Judd specifies four characteristics of Wundt's thought as influencing him and as accepted by him. These are voluntarism, creative synthesis, the historical method and social psychology. All of these can easily be recognized in Judd's writing and thinking.

Wundt's voluntarism was expressed in his doctrine of innervation. It was James' sharp criticism of this doctrine that was largely responsible for the breach between the two men, a breach which reputedly led Wundt to block the translation of James' psychology into German. The disagreement was particularly unfortunate since it concerned only a detail, and the two men were equally emphatic on the fundamental importance of the motor processes in mental life. Judd exemplified this emphasis in his experimental work, his theoretical formulations and his practical applications. For example, he interpreted space perception, his first object of study, and perception in general as resting primarily on motor processes.

For all his stress on behavior Judd was saved from the excesses of behaviorism by the concept which he calls creative synthesis. He held, with Wundt, that when forms of behavior or of experience reached a certain complexity of organization, new phenomena might emerge which were different in kind and not merely in degree from the lower forms. Such new forms of thought, he held, accompany the development of language, which he regarded as one of the chief factors in human

mental life. He protested that the higher mental processes, which are distinctively human, cannot be explained in terms of the simpler forms of behavior which are characteristic of subhuman animals. He acknowledged and recognized the importance, within limits, of simpler behavior in man but denied that it could be used to explain distinctively human experience.

Judd maintained that the common view that Wundt was mainly an experimentalist ignored his extensive work on *Völkerpsychologie* which came after most of the American students did their work in Leipzig. To this was related Wundt's treatment of social psychology because his work in this area was based largely on the development of social institutions. Judd's own work in this field is probably not as well known as is his experimental work on individual psychology, since it was done after he had transferred to education. It constituted one of the chief bases of his educational doctrine.

Returning to the United States with a Leipzig Ph.D. at the age of twenty-three, Judd devoted the next thirteen years of his life to teaching, writing and research in psychology, with minor excursions into pedagogy. By 1909, at the age of thirty-six, he had become full professor and Director of the Psychology Laboratory at Yale, had been elected president of the American Psychological Association and had been appointed Head of the Department of Education and Director of the School of Education at the University of Chicago. In the intervening time he had taught for two years at Wesleyan, three years at New York University, one year at the University of Cincinnati and seven years at Yale. During this time he had published nineteen reports of experimental studies, seven general articles in psychology, four articles in educational psychology, translations of three editions of Wundt's *Outlines of Psychology*, a book on educational psychology for teachers, a general textbook in psychology and a two-volume laboratory manual in psychology.

When Judd became Director of the School of Education at Chicago the office had been vacant since the resignation of Dewey in 1904. The institution was a rather loose federation composed of a department, at that time merged with the Department of Philosophy, a College, derived from the Chicago Institute founded by Colonel Francis Parker, an elementary school, founded by Dewey and his wife, and a high school derived from two private high schools of Chicago. The School could hardly be said to be a well-organized unit. The department dealt largely in theory, the college was devoted to the perpetuation of Colonel Parker's ideas and the laboratory schools were not closely integrated with either the college or the department. Judd addressed himself to the task of developing the advanced study of education and thus making of it a fit subject to be included in the curriculum of a university. The college lingered on for some years, giving degrees to teachers, and then was discontinued. The two schools were brought into closer relation to the department by the appointment of a superintendent.

The keynote of the work of the Department of Education under Judd was the scientific study of education. He gathered about him a nucleus of young men who had had scientific training, and gradually added to them men who had received their Ph.D. in the department itself. At the time of his retirement in 1938, there were fifteen full professors in the department. Of these, two went to Chicago with Judd, three others had been trained elsewhere, but ten had received their degrees in the department itself. One of his great

achievements was the building of a department made up, in the main, of these men. Their names deserve to be recorded: A. J. Brumbaugh, Guy T. Buswell, Newton Edwards, William S. Gray, Karl J. Holzinger, Leonard V. Koos, R. L. Lyman, W. G. Reavis, Floyd W. Reeves and R. M. Tryon. These men, together with their associates and their chief, put out a volume of work during the twenty-nine years of Judd's incumbency that was impressive both in amount and in influence.

Judd himself continued his prodigious productivity. A rich stream of articles flowed from his pen, totaling more than 300 after 1909. For many years he edited the two journals, *The Elementary School Journal* and the *School Review* and contributed ten pages of editorial comment and news notes to each journal each month. He wrote 123 articles for Monroe's *Cyclopedia of Education*. He produced eight additional textbooks, two in collaboration. He brought out one experimental monograph and participated in four others. He conducted two school surveys and took a major part in three others. He prepared a number of important official reports, such as the volume on education of the series on Social Trends authorized by President Hoover, and the study of research in the federal government. His last work was the preparation of textbook materials in the social studies, which he worked out in collaboration with the staff of the Santa Barbara schools and which was the culmination of life long interest and study in this field.

During his entire academic life, Judd carried a full teaching load in addition to heavy administrative responsibilities. He was a master teacher. The senior class at Yale voted him the best teacher in the college—this in a subject that had not been among the most respected. James Truslow Adams reports that when he took the course with Ladd many of his classmates read novels and newspapers during the lectures. Judd himself writes that the course had become a snap course for athletes and other featherbedders. The second time he gave it the enrollment dropped one-half. Within a few years, however, he built up the course to its former size. His popularity was due, not to making the course easy but to the rich content of the course, good organization, the free use of demonstration and visual presentation, clear exposition and lively and enthusiastic delivery. These qualities made Judd throughout his career one of the great teachers of his generation. They also made him one of the most sought after public speakers. Someone counted the number of papers read at the midwinter meetings connected with the Department of School Administrators of the NEA during a ten year period. Judd had delivered fifty-nine and the next in order had given forty.

Judd made a distinguished record as an administrator and as a national leader in education. He had a tremendously stimulating effect on all his associates. He held everybody, including himself, his colleagues and his students to the highest intellectual and ethical standards. His relations with all confrères were characterized by frankness and honesty in the highest degree. While he took full personal responsibility for administrative decisions, he adhered punctiliously, both in theory and practice, to the principle of academic freedom. He had a creative vision of the possibilities of any institution or organization with which he was connected and was always ready to throw his full energy into the realization of his vision. All the persons or institutions who came into contact with him felt the impress of his touch.

Judd's leading psychological ideas

have already been mentioned. He emphasized activity as equal to, if not more important than, sense impression as a factor in experience. He laid great stress on the organization as contrasted with the elements of experience, and held that more complex forms of organization may constitute qualitatively different experiences than simpler ones. He believed that the historical method gives data of equal importance to the experimental and that the background of social institutions is a major determiner in the individual's mental development.

These conceptions influenced profoundly Judd's theories of education. For example, he held that the aim of education is to develop ideas and the ability to form ideas and derive generalizations rather than to form habits by means of routine repetition and training. This point of view led him to take a strong stand on the question of formal discipline or transfer of training. Since the outcome of education consists of ideas and the ability to think, it is not confined to a particular content or to particular habits. It is general in its essential nature and therefore applicable to a wide range of particular data.

The emphasis on social institutions, the products of social evolution, such as language, mathematics, the arts, government or religion led him to stress the importance of adaptation to the cultural inheritance as over against spontaneous individual development as the basic process in education. Consequently he protested against the more extreme forms of progressive education and maintained that it is the business of the school to lay out a program of subject matter to be learned and to set up standards of performance for the pupil to reach.

While Judd made a place in his psychological and educational theory for emotion and for art, he himself pursued the methods of scientific thought and inquiry. His predominant method of thought was that of analysis, a method in which he was highly skilled. He approached art and emotional experience as objects of intellectual analysis. Furthermore, he analyzed them chiefly with reference to their place in the evolution of culture rather than to their character in the experience of the individual. He gave more attention to the functions which art and religion perform in society than to their distinctive contributions to the development of personality or to their essential nature. His acceptance of their presence in the curriculum, therefore, lacked something of the warmth with which he advocated the subjects that involve abstract thought and generalization.

What Judd's influence on 'pure' psychology would have been had he continued in that field is difficult to estimate. The functional point of view that he represented was soon submerged by the radicalism of the behavioristic point of view. He would doubtless have exercised powerful influence in preserving a more balanced emphasis. In fact, his doctrine of the importance of the organization of experience of ideas, and of generalizations contains much that was later brought out in the counter revolutionary movement of Gestalt and 'field' psychology. These strains in his thinking were more than mere suggestions, such as one might find in the writings of most psychologists. They were dominant notes in the harmony of his thought.

Judd's influence on the education of his generation has been very great. As has already been said, he was one of the foremost leaders in the promotion of the scientific movement in education, being rivaled only by Thorndike. He promoted this movement by his own writing and research, by his organization of the Department of Education at Chi-

cago and by his wide applications of scientific methods in school surveys and other practical studies. He also exerted an enormous personal influence through individual consultation, speaking and membership on boards and in organizations. His statesmanlike attitude, quick and penetrating intellect, driving force and superb power of expression carried great weight in any group. His leadership has had much to do with shaping the educational policy and procedure of the present, and will, I believe, continue to be influential far into the future.

FRANK N. FREEMAN
University of California

PERCEPTUAL ABSTRACTION AND ART [1]

BY RUDOLF ARNHEIM

Sarah Lawrence College

I. Introduction

Art and abstraction seem to be incompatible if the two concepts are taken in a widely accepted sense. The artist is said to offer representations of concrete, individual cases, whereas an abstraction is often defined as presenting constituents common to a number of particular cases in a sum or configuration which cannot be represented by any concrete, individual case. Any particular object, *e.g.* a table, allows visual representation, but such concreteness seems to be denied to the abstract concept 'table.' Again, abstraction is often thought of as an intellectual process of selection, which elaborates registrations obtained through the senses, whereas the artistic process is essentially non-intellectual, based on perception, intuition, feeling, etc.

On the other hand, 'abstract art' has become a familiar term. And even apart from this extreme instance it seems characteristic of many works of art, and particularly of many of the best, that they represent visual reality in a simplified fashion; they present types of objects, their general meaning rather than images of individual cases only—an achievement which sounds much like abstraction. The following attempt to examine some aspects of the relationship between art and abstraction presupposes a revision of certain psychological concepts. This re-interpretation will eventually require a much more thorough justification than the one offered in this paper. Apologies are also in order for the apodictic manner in which, again for the sake of brevity, these psychological propositions are put forward in what follows.

II. Perceptual Abstraction

A child draws a human head as a circle. This is not an attempt to reproduce the specific outline of a particular person's head but rather a general form quality of a head, of heads in general—namely roundness. Roundness is commonly thought of as an abstract concept. As such it can be attributed to many or all heads, but no particular head ought to be able to represent it concretely to the eye. Yet, the child's circle is more than a mere sign which stands for an intellectual concept, in the way in which ∞ stands for infinity. It is an image, a generally accepted image of that roundness which is common to the shape of heads. The impossible seems achieved—a perceptually concrete representation of the abstract.

The child's circle is no less a concrete individual case than a photograph of any of the particular heads for which it stands. But it is a representation that eliminates many of the perceptual characteristics of heads and limits itself to a form which renders the structure of roundness in a pure, clear-cut way. Thus the general quality of roundness which is drawn from individual heads can not only be defined in an intellectual concept, but the particular structure which it designates and which is realized less clearly in the shapes of other individual cases can be presented to the eyes in a concrete, individual form in which this structure is stripped

[1] The present paper is one of a series of studies on the Gestalt psychology of art which was prepared under a fellowship of the John Simon Guggenheim Foundation.

of many accidental complications. Such a purified, even though concrete, presentation of structural qualities seems to fulfill the requirements of a true abstraction.

The contradictory use of 'concrete' and 'abstract' in the foregoing is meant to illustrate the ambiguity of these terms. If we call 'concrete' everything that is perceivable, then the circle is just as concrete as a photograph of a head. But within the realm of 'concretely' perceivable things the circle may be described as an abstraction of the head. In the following, the term 'abstraction' serves to describe any simplified rendition of a (concrete) stimulus configuration.

Abstraction in primitive representation. Artistic abstraction involves a puzzling paradox as long as one considers abstraction as an intellectual elaboration of perceptual raw-material and therefore as an operation that can be performed only at a relatively high level of mental development. In the field of art—and this is probably true also for the psychology of thinking—highly abstract forms appear at the most primitive stages, whereas highly realistic representations are found in culturally late periods such as Hellenistic or Renaissance art. The pictures made by a child or an American Indian or a piece of early Egyptian sculpture show a high degree of abstractness whereas Pompeian paintings or Michelangelo's David approximate 'photographic' likeness so much more closely that less abstraction seems to have been needed to attain them (5). The abstractness of children's drawings and other primitive pictorial representation is commonly explained by what may be termed the intellectualistic theory. The formula, "the child draws what he knows rather than what he sees" has become almost an article of faith. A typical exposition of this theory is given by Goodenough (14), who clearly indicates that by drawing from knowledge she means drawing from intellectual concepts, as distinguished from memory images. Frequently children's drawings are called 'ideoplastic,' meaning representations which according to the author of the term, Verworn (23), are derived from what the draftsman thinks and knows of the subject rather than from a memory image. The intellectualistic theory seems to have been suggested by the external product, the child's drawings, rather than by what is known about the child's mind. In fact, a view according to which children create images of visible things by means of intellectual concepts is in striking contrast to the general observation that at the early stages of development mental life relies most directly on perceptual experiences. Is it probable that for the purpose of producing visual images from visual objects the child will choose the sophisticated detour via intellectual concepts? In particular there is no evidence that young children possess the highly theoretical concepts of form, direction, proportion, etc., which they would need to solve the task at a non-visual level. Probably the intellectualistic theory owes its origin and longevity to the fact that as long as perception is considered a purely passive 'photographic' registration of the retinal image striking deviations from that image can only be explained by the intervention of higher mental processes, such as intellectual conceptualization.

The attempt has also been made to account for the style of children's drawings by asserting that they are done from memory rather than from direct observation. The gradual transformation of memory images is likely to play a role in the process, and experiments on the memory of form suggest in fact that images change in the direction of simplification, symmetry, etc. (17, pp.

493–506; 26, pp. 77–91). However, a discussion of this point seems unessential here because it is known that children's drawings which are done directly from the object do not differ in any important respect from memory drawings, and this not only when the child pays little attention to the model, but also when he concentrates on faithfully committing to paper what he is observing. Thus, the whole problem is already contained in the child's pictorial account of direct perception.[2]

Priority of global perceptual features. A less constrained explanation seems to suggest itself if one abandons the traditional conviction that structural whole-qualities like roundness are derived from individual percepts as a secondary, intellectual elaboration of the sense material. Gestalt research suggests that such global characteristics are not only directly perceivable but must even be considered the primary perceptual phenomena. They seem to strike the eye even before the more specific detail of a visual object is grasped. Gellermann (11), for instance, has shown that young children and chimpanzees are able to transfer learning of one specific triangle to triangles of different form, size, position, etc.—an achievement which had been considered impossible for anybody who had not developed the intellectual concept 'triangularity.' In Koffka's experiments on memory images (26, pp. 43–44; 16) subjects often reported that they saw general characteristics of form, color or movement such as the shape of a coin or the fluttering of a flag, but not the further details necessary to determine the particular kind of coin or flag which appeared in the image.

If it be true that global, general features can be directly perceived and form the basic content of percepts rather than having to be distilled intellectually from a number of faithful 'retinal' records, if it cannot be maintained that "from the recognition of individual objects the child progresses by imperceptible stages to the recognition of classes of objects" (14, p. 67) but if instead the child grasps global class characteristics first and only secondarily differentiates between individual cases, then no higher mental processes are needed to account for the abstract character of the drawings. Rather can this abstractness be explained by processes which occur largely at the perceptual level, *i.e.*, in a way that is more in keeping with the basic findings of child psychology.[3] This is also the first step towards a solution of the above mentioned genetic-historical paradox, which is due to another ambiguity in the term 'abstraction.' Abstraction may simply indicate 'a smaller quantity containing the virtue or power of a greater' (Samuel Johnson) regardless of how this 'smaller quantity' has been obtained. Or it may mean the process indicated by the etymology of the word, *i.e.*, the act of reducing a configuration to a less complex one, such as in the case of a scientist who

[2] Another attempt to attribute the discrepancy between primitive representation and 'photographic' faithfulness to non-visual processes has been made recently by Löwenfeld (20, 21), who asserts that drawing in plan or sideview springs from the essentially tactile experience of 'haptical' persons while visually minded persons draw 'objective,' *i.e.*, perspective views. The theory ignores the fact that owing to what is known as the constancy of form people do not see and therefore do not draw perspectively unless their cultural environment happens to train them in that direction.

[3] The occasional instances in which the representation is really determined by intellectual knowledge show convincingly how untypical this procedure is. For instance, the child will come to draw a hand with the exact number of five fingers—as a rule after he has used star patterns which render the visual structure of the hand through an indefinite number of radial lines.

succeeds in decreasing the number of concepts which he previously needed for the description of certain phenomena or of an artist who at a certain stage of his evolution may come to prefer patterns simpler than the ones he employed before. The condition indicated in the first definition may come about without the process indicated in the second. The highly abstract forms which characterize early stages of representation are not due to the simplification of previously more complex patterns. Rather do they spring, in perception as well as in representation, from a priority of simple, global forms. These may develop gradually into more complex ones, such as are required for more 'realistic' representation. It follows that highly realistic images must not be interpreted as a direct registration of photographically faithful percepts but rather as the result of the gradual refinement of originally more abstract form patterns.

Perceptual concepts. A psychological difficulty arises if one tries concretely to realize what it means to see a general quality like roundness in a specific outline such as the contour of a human head. So far, Gestalt psychological formulations seem to state only that among the possible groupings of a given stimulus material the one will be chosen which yields the 'best' structure and that features which constitute the basic whole-structure of a configuration have a tendency to stand out and to be perceived first. That is to say, a selection or distinction of actual parts of the configuration on the basis of their structural function is said to occur. It would seem, however, that no mere grouping of or selecting from what is retinally given in the outline of a head could lead to the perception of 'roundness.' Experiments have also shown that if the influence of the stimulus configuration is weakened through short exposure, dim illumination, distance in space or time, etc., figures are perceived which differ from the ones actually exhibited not by mere lack of completeness; rather do patterns result which represent the structure of the model in a simplified way, by means of regular, often symmetrical forms, which quite frequently were not contained in the model (**17**, pp. 141–144). It is as though the margin of freedom yielded by the lessened stimulus control enhanced a tendency of the receiving sense organ spontaneously to produce simple, regular form. This tendency may be basic for perceptual processes in general. Perhaps perception consists in the application, to the stimulus material, of 'perceptual categories,' such as roundness, redness, smallness, symmetry, verticality, etc., which are evoked by the structure of the given configuration. When we see a human face is there, even as a first stage, a passive recording of all or some of the specific contours, sizes, shades of color, in 'and-sum' or whole-configuration? Does not seeing a face mean producing a pattern of such general qualities as the slimness of the whole, the straightness of the eyebrows, the forward sweep of the nose, the blueness of the eyes? There is a fitting of perceptual characteristics to the structure suggested by the stimulus material rather than a reception of this material itself. Are not these whole-patterns of categories of shape, size, proportion, color, etc., together with the expression they carry, all we get and use when we see, recognize, remember? Are these categories not the indispensable prerequisites, which permit us to understand perceptually? [4]

[4] One is reminded of Dante's "Vostra apprensiva da esser verace tragge intenzione, e dentro a voi la spiega, sì che l'animo ad essa volger face" (*Purgatorio*, canto XVIII, 22). Owing to the double meaning of the verb 'spiegare' the faculty of apprehension is described in this passage as 'unfolding' the

And does this not apply regardless of whether we content ourselves with the broad over-all impression of an object or examine its minutest detail? The number, kind, and subtlety of these categories will vary somewhat from individual to individual, but the more clearcut and constant the structure of the stimulus configuration, the more definitely will it determine the pattern of categories that is the percept.

The perceptual categories can be described as general and abstract because they are not limited to any one object but are discovered in and applied to any object that fits them. They are not intellectual distillates gained through experience from a great number of cases, but rather spontaneous 'pure forms of sensory perception' (to borrow Kant's term), explainable possibly by a tendency to structural *'prägnanz'* in the processes that take place in the visual cortex in response to stimulation. Our assertion is that the individual stimulus configuration enters the perceptual process only in that it evokes a specific pattern of general sensory categories, which *stands for* the stimulus in a similar way in which in a scientific description a network of general concepts is offered as the equivalent of a phenomenon of reality. Just as the very nature of scientific concepts excludes the possibility of their ever seizing the phenomenon 'itself' percepts cannot contain the stimulus material 'itself,' either totally or partially. The nearest a scientist can get to an apple is by giving the measurements of its weight, size, shape, location, taste, etc. The nearest a percept can get to the stimulus 'apple' is by representing it through a specific pattern of such general sensory qualities as roundness, heaviness, fruity taste, greenness, etc.

If this theory be acceptable the elementary processes of perception, far from being mere passive registration, would be creative acts of grasping structure even beyond the mere grouping and selecting of parts. What happens in perception would be similar to what at a higher psychological level is described as understanding or insight. Perceiving would be abstracting in that it would represent individual cases through configurations of general categories. Abstraction, then, would start already at the most elementary level of cognition, namely with the acquisition of the sensory data.

This view requires us to speak of 'perceptual concepts.' For instance, we have to distinguish between the perceptual concept 'weight,' which refers to the kinaesthetic experience of heaviness, and the intellectual concept 'weight,' defined as the force with which the earth attracts an object. Both equally fulfill the requirements of concepts in that they are general qualities applicable to specific cases.

The distinction between percept and concept also would seem to disappear. If the perception of an individual face is an abstractive process of the sort we have described, then the visual concept which the observer obtains from that face is not different in principle from the visual concept of 'the Chinese face' which we may have obtained from a number of Chinese faces. Both are attempts to create perceptual patterns adequate to their reference, and it does not matter whether this reference consists of one case only or of several whose structure has something in common.[5]

images of external reality but at the same time as 'explaining' them to the mind.

[5] The term 'general' is significantly ambiguous. Etymologically it refers to something that is common to a number of cases, like the German *'allgemein.'* However, when we speak of the 'general outlines' of a particular face we do not mean to refer to what it has in common with others but rather to its main, dominating, over-all features, which may remain untouched even when much detail is

Representational concepts. The psychology of artistic abstraction involves not only problems of perception but also of representation. Perceiving a thing is not yet representing it. Still, considerable writing on the theory of art is based on the tacit assumption that a pictorial representation is simply a copy of a percept or, at least, that the percept of the reference or model is, as it were, the raw material of representation from which the final shape of the work is derived by some kind of cosmetic transformation, namely by the mere omitting or adding of elements, by changing or distorting, by dissociating and reassembling, etc.[6] We have assumed that what we called the perceptual concept is not derived from the stimulus configuration by mere selection, grouping, or rearrangement, but is rather its structural equivalent, a pattern of perceptual categories. In the same way a pictorial representation is neither a copy nor a transformation of a perceptual concept. Undoubtedly the young child who draws the circle sees more than sheer roundness when he looks at a human head. Before he can draw at all he is capable of telling different people from each other. The perceptual pattern is refined beyond anything indicated by the child's drawings. Nor can the difference between what is perceived and what is produced on paper simply be explained as a lack of technical craftsmanship. By and large the young child, and certainly the primitive artist, already possess enough motor skill and visual control to produce the image they intend to. A child may not be able to draw a perfect circle, but as a rule he achieves enough of an approximation to make his intention quite clear to the spectator. The circle is not an unskilful rendition of a more complexly or more realistically intended form, but a fairly exact representation of what the draftsman meant to produce.

The percept or memory trace of an object of reality does not generally consist of lines or brush-strokes and is for the most part not two-dimensional. It is the image of a three-dimensional body delimited from its environment by hue and brightness contrast, etc. Some of its qualities can be reproduced in drawing and painting, others not. This means that wherever they cannot be reproduced directly an equivalent must be developed from the means offered by the medium of representation. This is necessary also for an even more important reason. If perceiving consists in the creation of patterns of perceptual categories, adequate to the stimulus configuration, and if the artist's task includes the representation of such patterns, then he has actually to invent a pictorial form which more often than not cannot simply be 'read off' from the percept. It is true that a lamp-post easily suggests the straight lines by which it can be represented. But the roundness of a head is not present as a traceable outline, it is a whole-feature whose pictorial equivalent must be invented. A mechanical reproduction through photography or plaster mould will generally allow identification of the objects and render some of its characteristics, but its form will be, at least

changed. Yet the two meanings of the term are closely interrelated. Sensible generalizations are drawn from individual cases that are similar with regard not merely to any element, but to essential structural features. That is to say, the 'general' features of a particular specimen are likely to be those which it shares with others of the same genus.

[6] Two examples selected at random may illustrate this theory. John Constable: "Yet in reality what are the most sublime productions of the pencil but selections of some of the forms of nature, and copies of a few of her evanescent effects?" J. A. McN. Whistler: "Nature contains the elements, in color and form, of all pictures, as the keyboard contains the notes of all music. But the artist is born to pick, and choose, and group with science, these elements" (13).

partially, chaotic, *i.e.*, incomprehensible if compared with a genuine representation, which presents the image of the model as a pattern of well-defined form. Representation consists in 'seeing into' the stimulus configuration a pattern that fits its structure—often a laborious or even insolvable problem—and then to invent a pictorial counterpart for this pattern.[7] This can be done in innumerably different, all equally valid ways, as a visit to any art museum will tell. The sinuous lines which van Gogh used for the representation of cypresses were not given in the stimulus configuration nor did the perceptual pattern which the artist produced in response to the stimulation consist of wavy strokes. Rather are these strokes the pictorial equivalent of his perceptual concept, its materialization as tangible form, a translation into the pictorial medium rather than a reproduction.

Thus representation consists in creating, with the means of a particular medium, an equivalent of a perceptual concept. The circle is directly derived from a graphic medium whose principal means are one-dimensional lines. The percept which gave rise to the circle would lead to a different representation if the latter were attempted with a brush, in clay, with cubic blocks, or in weaving. But whatever the medium, there will be structural similarity of the representation and the perceptual concept. Such a structural similarity of configurations in different media has been termed isomorphism in Gestalt theory.

[7] This process should not be mistaken for a 'projection' of the kind which produces an imposition of essentially subjective meaning on a pattern of deliberately vague structure, such as for instance in the Rorschach test. Representation always involves an interplay between the structure of the stimulus configuration, the formative processes in the visual cortex, and the attitude towards reality of the artist and his time.

The analysis shows that pictorial representation presupposes more than the formation of a perceptual concept. A way must be found to translate the percept into tangible form. Obviously this task is not performed by the pencil on paper, but by the mind that guides the pencil and judges the result on paper. This requires what we propose to call 'representational concepts.' To return to our example: roundness is the *perceptual* concept which renders a structural particularity of the stimulus configuration 'head'; the conception of a circular line by which roundness can be materialized as a tangible form is the *representational* concept needed to produce the circle on paper.[8] The translation of perceptual concepts into patterns which can be obtained from the stock of forms available in the particular medium will precede the actual drawing, continue during the drawing and then again be influenced by what shows up on paper. Representational concepts are dependent on the medium for which they explore reality. When looking at a human figure a sculptor forms a representational concept very different from the one of another artist who looks at the same figure with 'woodcut-eyes.'

Recent investigations, particularly the pioneer study of the art educator, Gustaf Britsch (6) and the work of his disciple Schaefer-Simmern (22), have formulated some of the rules according to which artistic form develops organically from the simplest shapes and directions (circle, straight line, horizontal-vertical framework) to more and more complex ones. Psychologically this means that, for instance, the art of children and primitives cannot be understood as long as one describes

[8] After what has been said before the use of the term 'concept' will not be misunderstood to mean an intellectualistic interpretation of perception and representation.

them negatively by their mere falling short of what one chooses to call 'correct' representation. Rather are we in need of a psychological re-evaluation, similar to the successfully achieved esthetical one. Primitive art must be considered positively as the manifestation of elementary representational concepts which even at the earliest levels are capable of unified, consistent, and adequate representation to a degree which is often lacking in more 'civilized,' 'advanced' artists. This new turn of the theory gives support to the art educator's claim that a human being's innate capacity for representation is nipped in the bud if early in his training he is asked 'faithfully' to reproduce a complex subject such as a human model with its great deal of intricate detail or if he is driven to imitate the advanced technique of the teacher. Such a procedure hinders the process of growth which is necessary to carry the student through a gradual enrichment of his representational concepts to a level at which he can genuinely conceive and understand highly complex representations. Owing to the innumerable disturbances which in our time interfere with the natural unfolding of such potentialities in the various aesthetic fields many people are needlessly deprived of the capacity of representing what they see in organized form and enjoying sincerely what is offered in museums, concert halls, etc. The new approach is likely also to reveal an intimate relationship between the development of perceptual and representational concepts on the one hand and of mental growth in general on the other hand, particularly in thinking. The interaction of the capacities to organize perceptual as well as thought-material of increasing complexity, the birth of thought, insight, understanding in the realm of perception and their development to more theoretical, intellectual processes deserve thorough psychological study. This will provide a more solid basis for what at present is functioning under the name of visual education on essentially empirical, practical principles. In particular, such investigations are likely to show that the merits of visual teaching-material are not limited to the fact that they offer concrete, simple, near-to-life stuff to the young intellect, but that the very perception and visual representation of such material, quite apart from the intellectual elaboration, already contain processes of grasping and organizing of a kind needed in higher mental operations.

Representation requires abstract form. Artistic abstraction, then, is not a selective reproduction or a rearrangement of the model-percept but the representation of some of its structural characteristics in well-organized form. The meaning and expression of an object becomes manifest only to the extent to which the representation consists of forms which are well-defined with regard to their shape, proportion, direction, color, etc. It seems relevant to emphasize this particularly with regard to the traditional theory which derived expression from what the observer knows, by past experience, about the psychological or physical state of the objects represented. The picture of a beast of prey was supposed to convey the expression of strength or ferocity because the observer knows that such is the nature of these animals or because, by empathy, he puts himself in the psychological and physical state suggested by the picture. Actually an image cannot convey artistic expression unless the form pattern by which the subject is represented contains structural characteristics that carry the desired expression. The drawing of a panther in a Persian illuminated manuscript (27) superbly renders the powerful but sup-

ple movements of the beast, which remind one of a steel spring. This is not attained by a careful reproduction of the outlines which might be found in the photograph of a panther but rather by the smooth but consistently bent curves which stand for the animal's body as a whole as well as for every detail of its outline. The picture interprets the expressive qualities of the draftsman's perceptual concept 'panther' through an adequate form pattern derived from the medium of representation, thus showing *the* panther through *a* panther and indeed creating an image of supple strength whose validity goes even beyond the presentation of a species of animal. An abstract, general content is conveyed by a specific individual image.

The organized pattern of lines which in any work of art is the main carrier of the meaning and expression conveyed to the spectator differs only in complexity from the circles and straight lines of a young child's drawings. The form factor which is so prominent in the highly abstract style of primitive representation, is equally present, though less striking, in even the most realistic work of art if it deserves the name of genuine representation. Thus primitive representation is particularly enlightening in showing the role which abstract form plays in any kind of representation. This insight is hampered by the intellectualistic theory which was discussed before with regard to children's drawings. The theory has been used more generally to provide psychological explanations for two extreme kinds of artistic representation, the one formalized, stylized, often geometrical, the other naturalistic, approximating photographic faithfulness. Verworn (23) explained the former as 'ideoplastic' art, allegedly based on knowledge or thought, the latter as 'physioplastic' art, a mechanical copy of the 'retinal' projection. The theory is still alive in the minds of art theorists.[9] Apart from being based on an antiquated psychology or perception, such a theory creates an artificial dichotomy between what it considers two kinds of art, the one abstract and the other concrete, different in their principles of representation and in the psychological processes from which they spring. As we said before, this prevents the essential insight that the form element which is so prominent in highly abstract art is indispensable and exactly of the same kind in any naturalistic representation which deserves the name of art. On the other hand the theory neglects the fact that perceptual observation contributes even to highly stylized work. When a South Sea islander paints the sea moved by the wind as a rectangle striped with oblique parallel lines, essentials of the model's visual structure are rendered in a simplified, but entirely un-'symbolic' manner. Albrecht Dürer's highly naturalistic studies of a hand, a face, a bird's wing are works of art only because the innumerable strokes and shapes form well organized, even though complex, patterns thus presenting an abstraction that interprets the subject. The two types of representation are nothing but the extreme ends of a scale which allows all possible styles of art to be arranged in a sequence leading from the pure ornament through all degrees of abstractness to extreme realism.

Consequently it seems insufficient to define the process of representation in relation to but one basis or point of departure, namely the stimulus configuration of the objects portrayed. Representation is not simply a more or less faithful reproduction or simplification or variation of the perceptual material.

[9] As a recent example see Bunim's distinction of 'conceptual' and 'optical' representation (7).

Two opposite points of departure are needed, on the one side the stimulus material of the object and on the other side form, the indispensable precondition of visual understanding. Perceiving as well as representing a thing means finding form in its structure. The patterns of 'non-objective' art, if considered from the point of view of the world of natural things, are extremely abstract in that they reduce the representation of reality to a visual equivalent of the universal physical and psychological forces that underlie nature and life and of their interplay, which can be expressed as harmony and disharmony, dominance and coordination, contrast and similarity, movement and rest, equilibrium and disequilibrium, and so forth. From the opposite point of view, however, *i.e.*, from the point of view of form, the basic, non-objective patterns are not abstract. They are the very elements of visual comprehension, the building-stones of the complex composition which the artist creates in order to represent the structure of the world in the way his temperament makes him see it.[10]

Form is sometimes considered a mere spice added by the artist to the representation of objects in order to make it pleasurable. Composition is often evaluated without any reference to the subject expressed by it. In opposition to this view it must be asserted that, in art as well as in representation in general, form is an indispensable prerequisite for the perceptual characterization of the content. For instance the invention of photography has not eliminated drawings for the purpose of scientific illustrations, architectural and other technological drafting, etc. A photograph gives in some ways a more faithful reproduction of a medical preparation, a building, or a machine. But what the picture is meant to show is not the object 'itself' but rather some of its physical characteristics that can be conveyed by its appearance, such as shape, relative size of parts, etc. This information can be given only by means of lines, color and brightness values, shading, etc., and the more clearly the essential visual factors are brought out the better. The draftsman can reduce the representation to these essential factors. If it is important that two parts of an engine be shown as overlapping he can employ a pattern of contour lines which gives the effect of overlapping. If an indentation, a red speck, a curvature are what the physician or the biologist is to look for, the draftsman applies the rules of perceptual organization which govern these visual effects. That is to say, the draftsman interprets the object by bringing out relevant form characteristics. He produces an abstraction of the object's visual appearance by translating it into clear-cut form. This, and only this, would seem

[10] Goldstein (12, p. 40) reports the case of a brain-injured patient who is unable to reproduce the V-shape with two sticks, but has no trouble when the model is turned upside down because now it means a roof to him whereas the V was 'nothing.' Goldstein explains that in the case of the 'roof' the patient needs to deal simply with a known concrete object while in the first case he would have to act on the basis of abstract ideas. This explanation is an example of what we mean by considering representation only from one basis, namely the world of natural things. Simple figures are not primarily abstract derivates from concrete objects of the environment but are rather the most immediately comprehensible stimulus configurations in their own right. They do not have to be related to objects in order to be understood visually. On the contrary, they are the closest structural equivalents of those perceptual categories which make it possible to identify objects. One does not need a roof to grasp a $\wedge$; one needs the $\wedge$ to be able to see a roof! Whatever the source of the patient's difficulty, it does not seem to be due to the fact that he is unable to produce or employ abstractions allegedly needed by the healthy person for dealing with basic visual patterns.

to be representation. Similarly, in a representational work of art, composition has the task of conveying, in the structurally most clear-cut way, such form characteristics as carry the desired expression.

III. The Psychological Meaning of Artistic Abstraction

So far, this study of artistic abstraction has dealt with the perception and representation of objects without considering the larger psychological context in which these processes occur. But some of their essential aspects can be explained only if one takes notice of the fact that art is not the hobby of making reproductions, a game quite independent of other aims and needs, but rather the expression of an attitude toward life and an indispensable tool in dealing with the tasks of life. Thus, if we are confronted with the fact that entire civilizations for hundreds and thousands of years did not go beyond a level of abstractness which Western children overcome within a few years, it would be superficial to account for this apparent limitation by saying that the artists of these civilizations were simply too primitive to develop their representational concepts beyond a certain level of complexity. Such an explanation is valuable, for instance, when we analyze the artistic products of feebleminded inmates in Western institutions, but when it comes to Egyptian or African art, the work of the Precolumbians, the American Indian, or the European Middle Ages; or, for that matter, if we wish to understand certain modern art of our own time, then we must take into account the function of artistic representation in life and try to deduce from our findings why under certain conditions representational concepts remain at or return to a level of high abstractness. This is a complex subject to which historians, anthropologists, and sociologists have devoted their attention. The following notes are meant to indicate directions which an investigation could take with regard to our specific problem.

Form interprets environment. Highly abstract art can be disposed of as a primitive half-way achievement only as long as it is taken for granted that 'photographic' realism is all art's final aim. Actually an unbiased look at the history of art shows that only rarely and under specific cultural conditions has art pursued this aim while as a rule rather abstract styles of representation have prevailed, not as preparatory steps on the road to something more perfect but as the fully materialized, adequate expression of certain conceptions of life and functions of art in life. Thus it is necessary to account for the positive psychological values of artistic abstraction.

One answer to the question has already been presented in the second part of this paper. It has been pointed out that abstract representation differs from the corresponding stimulus configuration of the model in that it reproduces some essential features in a structurally purified way thus offering an interpretation of the model. This capacity is relevant for the explanation of the highly abstract style typically found in primitive art. The origin of highly geometrical or 'ornamental' forms as they are found in different periods all over the world, has been frequently explained either as stimulated by the observation of simple shape in nature (the disk of the sun, the straightness of the horizon) or as a carry-over from certain handicrafts, particularly weaving, which, for purely technical reasons, produce simple patterns such as triangles. These theories do not explain why simple shape, so rare in nature, should have been singled out and universally favored in the crafts of man,

nor do they tell why geometrical patterns should have been invented or retained where no technical conditions suggested them. If, however, abstract representation has an interpretative function, the style of primitive art may have to be related to the fact that man's orientation in his environment, so essential for his survival, takes place at first at an essentially perceptual level. In the child as well as in the primitive, theories about the forces which govern nature and life are derived from sense observations. Now, according to the view presented in this paper perceptual understanding is possible only to the extent to which the stimulus material can be accounted for by patterns of perceptual categories. The simpler these patterns, the easier the understanding will be. This leads to the supposition that representations in simple form are attempts of the young mind to make the sensory environment understandable by presenting it as well-organized form. If this be so, it will be evident that art, far from being a luxury, is a biologically essential tool to the child and to the primitive.

The functions of realism. Why did numerous cultural periods never pass beyond a stage of relatively high abstraction? The question is not likely to be answered adequately unless one realizes that it is just as necessary to wonder why in some instances artists came to strive towards the more and more faithful reproduction of what corresponds to retinal projection. Order and comprehensibility, introduced into the visual environment by well organized form, are not necessarily increased and indeed are easily endangered if the form patterns become more complex through increasing approximation to the 'photographic' aspect of things. Perspective distortions of shape and size, overlappings, accidental aspects and positions, momentary reflections of color and projections of light and shadow would, for the primitive, introduce a complication of visual reality which the elementary style of representation is able to avoid. The complex distortions of a nude painted by Tintoretto or Rubens do not convey the basic information about the structure of the human body which the child lays down laboriously through the creation of his 'schematic' man. What then are the psychological conditions which in some periods make art develop to a more faithful representation of the stimulus configuration?

Both the primitive and the man of the Western post-Renaissance world pay close attention to physical reality. But there are important differences. The modern scientist recognizes that the forces which determine physical events and which can be read off or inferred from the appearance and behavior of material things are functions of the physical objects themselves. On the contrary, the primitive thinks of these forces as residing in invisible substances which merely dwell in bodies. In consequence, it seems possible that detailed observation and representation of physical appearance and behavior which have become indispensable to modern science are much less meaningful to the primitive. The illustrations contained in the handbooks of our natural scientists are faithful and detailed to a degree of concreteness which would have seemed superfluous and even confusing to their colleagues in the Middle Ages, in ancient Egypt, or in an African tribe. A corresponding attitude towards material reality distinguishes the post-Renaissance artists and their public from those of many other civilizations. The best European art of the last centuries, even where it still used conventional religious subjects, expressed a philosophy of the here and now. The physical concreteness of Michelangelo's

figures, of Rembrandt's portraits, of Altdorfer's trees interprets and evaluates life in terms of material existence rather than presenting this existence as the mere object of immaterial powers.

The social function of art also changed in the post-Renaissance period. Art began to depict, for an ever-growing stratum of society, individual and transitory happenings of life. This called for a more realistic style.[11] Contrariwise, it is true for primitive as well as many of the higher and highest civilizations that the task of art consists in representing to the eye the meaning and the value of religion, government, etc. The superindividual dignity of the divine ruler, which is untouched by the contingencies of time, requires the generality of highly abstract representation. This is particularly true for cultural periods in which the perceptual world is accepted only as a means of illustrating ideas to the senses. Early Christian art withdraws from the highly developed realism of the preceding era to a highly abstract style which rejects accidental and individual appearance and irrelevant detail, emphasizes what is constant and lasting, and resorts to symbolical representation.[12]

The preference for balanced form. As pointed out before, form must not be considered merely in relation to the reality of environmental objects, whose images it creates, but is a reality of its own, a world governed by its own laws, namely the laws of perceptual organization. In representation, the organization of form is dominated by the task of creating a structural equivalent of the model-object. But apart from its interpretative function well organized form has a value of its own for the organism. It is a characteristic reflection of analogous tendencies within the organism. This is another psychological aspect of the artistic creation. An extreme example is offered by the 'ornament.' Credit is due to Kainz (15) for having pointed out as early as in 1927 that a more convincing explanation of ornamental form than the one mentioned above (p. 76) can be deduced from the Gestalt psychology of perception. We previously emphasized the priority of global perceptual features, which is suggested by these experimental studies. But equally relevant is the finding that in perception there is a tendency to create the most regular, symmetrical, stable form. This was the result of Wertheimer's investigation on the grouping of visual stimuli (24, 25). Other investigations (17, pp. 141–144) were cited above to show that when, through dim illumination,

[11] A cultural development which tended to separate religion, philosophy, art, science, and the pursuit of practical everyday tasks from each other has enhanced this realism to a point where it lost interpretative abstract form and degenerated into a mere indicator of the physical presence of desirable and otherwise emotionally 'thrilling' things. The extreme example can be found in our commercial 'art' and entertainment. Art becomes a substitute for the physical world and an escape to a more pleasurable fictitious reality. According to Kuhn (19) there is a relationship between artistic realism and civilizations based on exploitation and consumption.

[12] The term 'symbol' is frequently misused and has suffered from the devaluation to which essential concepts have been subjected in our time. The Byzantine artist uses a symbol when he represents the faithful Christians drawing strength from the spring of salvation through the image of two deer drinking from a fountain. But if the term is used to describe mere non-objective patterns or signs, such as words standing for their referents, or the representations of physical objects in primitive art (the 'symbolical' stage in children's drawings!), confusion is likely to result. In the psychology of dreams the term would seem to be misused where it refers to substitution on the basis of mere perceptual or functional similarity (Freud's sex-'symbols'). On the other hand, dreams succeed in concretizing psychological situations with an ingenuity and inventiveness that remind one of true artistic symbols.

short exposition, distance in time etc. the influence of the stimulus is weakened, the receiving apparatus acquires the freedom of exercising a formative influence on the percept. Under such conditions transformations result in the direction of more symmetrical, more regular structure. This would suggest that in perception there is a tendency to the best possible equilibrium, another instance of what Cannon (8) with regard to the organism as a whole has described as physiological homeostasis. The implication would be that well organized visual form produces in the visual cortex a correspondingly balanced organization. This may provide a physiological explanation of the psychologically unexplainable esthetic fact that well organized form produces pleasure.[13] It is an unsettled question whether pure 'design' is spontaneously produced by children and to what extent it exists in primitive art, but if the preference for well organized, 'good' form is a basic characteristic of the perceptual process, it seems entirely likely that there is a strong motive for the creation of such designs, apart from or combined with representation. It is true, modern art theorists have realized, that the great amount of merely decorative ornament in our time is due to a decay of original representational meaning and that much of what had been interpreted as mere decoration in primitive art is really representational (9). This progress in understanding, however, should not make us overlook the fact that there is a genuine psychological motive for well organized form as such.

Dynamic complexity of form. The pleasurable effect of harmony, symmetry etc., which is emphasized by classicistic art theory, can be derived from the above findings of Gestalt research. However, the organism does not tend simply to equilibrium, but strives to obtain a maximum of potential energy (18, pp. 319) and to apply the best possible equibrium to it. Aesthetically this may correspond to the old formula of unity in variety, *i.e.*, to the desire of organizing a maximum of dynamic richness in well-balanced form. Dynamic complexity can be obtained at any level of abstraction. A certain kind of modern art, for instance some of Picasso's work, uses only a few highly simplified representational elements for the construction of complex form patterns. The same is true, for instance, of the decorative designs on Peruvian pottery, the handicraft of the American Indian, or the Irish book illustrations of the early Middle Ages.

Realism, *i.e.*, increased concreteness, apart from creating new means of interpretation, serves to obtain pleasurable complexity. Adam (1) has pointed out that the term 'realism' has a double meaning. It may be understood as the faithfully detailed representation of objects "in themselves" but also as a method of picturing things "true to the optical impression of the model as observed at a given moment from a given angle." In both of these senses realism enhances complexity. Genuine drawings of young children do not use perspective, etc., that is, they are not realistic in the second sense. But within this highly abstract style, the

[13] Prof. Erwin Panofsky has indicated to the author that medieval philosophy offers parallels to this view. Thus Thomas Aquinas: *"Pulchra enim dicuntur, quae visa placent; unde pulchrum in debita proportione consistit, quia sensus delectatur in rebus debite proportionatis, sicut in sibi similibus, nam et sensus ratio quidem est, et omnis virtus cognoscitiva"* (*Summa Teologia*, pars I, qu. 5, art. 4). Coomaraswamy (10, p. 106) may have this passage in mind when he writes that, according to medieval aesthetics, ". . . if the eye is satisfied, it is because a physical order in the organ of perception corresponds to the rational order present in whatever is intelligible."

child often concretizes his representation in the first sense of the term 'realism' by rendering a great deal of detail, for instance, in the human figure the design of dresses and such individual characteristics as earrings, missing teeth, mosquito bites, etc. Apart from its representational value, such realism leads to a complexity of formal relationships which can be expected to be pleasurable not only to the grown-up observer but to the young draftsman himself. At a higher level, the formal charms of intricate detail may be studied, for instance, in German and Dutch art.

In these last examples, realistic attention to detail is combined with realism in the second sense of the term. The transformations of shape and size through perspective, the amputations through overlapping, the emphasis on some parts and elimination of others through light and shadow, the modification of local color through reflections are important new means for the interpretation of objects (4, pp. 47–94). At the same time, however, such realism permits a sophisticated playing with form, color, light, and texture, which provides an epicurean pleasure in its own right.

Abstraction expressing mental detachment. Our analysis has brought out the fact that form cannot be derived entirely from the objects represented in the work of art but is at the same time a creative contribution of the organism. Three creative tendencies of this kind have been shown to be inherent in the form of a work of art: tendencies towards (*a*) simplification, (*b*) balanced, regular, symmetrical patterns, (*c*) enriched structure. All three can be justified by genuine artistic purposes of representation and decoration. However, it is necessary to point out that under certain conditions any one of the three must be evaluated psychologically as a predominance of subjective factors caused by a disturbance of the attitude to objective reality.

(1) It is sound artistic principle (known in science as the principle of economy) that the form of any work should be as simple as its subject permits. In primitive representation highly abstract form has been shown to be the adequate expression of the elementary approach to grasping and rendering global structural features. Far from expressing detachment from reality, the primitive, and to some extent the child, ignore 'photographic' faithfulness in favor of the biologically important reality of 'essentials.' 'Monumental' styles of representation emphasize the higher reality of ideas rather than the reality of matter. Again, withdrawal from external reality may offer a chance for the expression of the subjective reality of the individual personality; music or nonobjective art, even though they do not require such an attitude, are most favorable to its manifestation. But in some cases, a high degree of abstraction may express detachment from reality, an impoverishment which leaves representation with nothing but the perceptually determined play of empty forms. Such a detachment can be explained as a consequence of the splitting-up of integrated culture into specialized activities (p. 78, footnote) which tends to conceal the philosophical, religious, social meaning of the individual's life, to destroy the artist's function in the community, and to reduce his task to a merely 'aesthetic' one.

(2) The tendency to simplification cannot be separated from the second tendency, to balanced, regular, symmetrical form. Just as in the above-quoted experiments (17, pp. 141–144) the perceptual mechanism produces transformations in this direction to the extent to which stimulus control is re-

duced, lack of contact with reality will lead to an overemphasis on form. Predominance of form is justified where decoration is the primary purpose. However, one speaks of a 'decorative' style in the negative sense when a weighty subject fails to impress its meaning on the artist, who is consequently guided largely by formal values, such as in the case of Aubrey Beardsley representing the story of Salome and St. John through ornamental lace patterns. In the 'doodles' of persons whose attention is absorbed by other tasks, the predominance of the perceptual tendency to well-balanced, regular forms often leads to decorative, but otherwise empty patterns; *i.e.*, psychologically central control is reduced and therefore perceptual organization assumes peripheral control. Such formalism caused by a detachment from the subject of representation is characteristic of much modern art of minor quality.[14] Psychologically, this kind of abstractness can be described as a symptom of the emancipation of perceptual function from external and internal stimulus control.

(3) Enrichment of the form pattern was described as providing new means of representational expression and an increase in genuine decorative values. Sometimes, however,—and this happens particularly in highly abstract styles—the subject, or at least the task of representing the subject, seems to keep so insufficient a hold on the artist that from few remnants of representation a complex pattern evolves which is not controlled by the representational purpose and often overgrows whatever representational elements exist in the work. It is a matter of aesthetic evaluation to decide whether some of the examples cited above (Picasso, Irish book illustrations) belong in this category or not. In this connection it seems worth while to point out that under certain conditions the realism of perspective deformations, foreshortenings, overlapping, etc. may also have to be evaluated negatively as a neglect of essential contents in favor of explorations in purely formal complexity. Photographic faithfulness, which involves distortions and amputations of the 'real' constitution of things, is so remote from the naïve conception of reality that even in our time a young artist has to undergo years of hard training and even to rely on mechanical devices of measurement and projection if he wants to accomplish 'correct' representation. This style of realism may come from a kind of artist who is detached from the values and objectives of reality and aspires to faithful reproduction for its own sake or is carried away by the stimulating charms of complex form. The aesthetic assertion that it did not matter whether a work of art represented a cabbage or a madonna came from a school of realists. Therefore, the rapid change from high impressionism to highly abstract styles such as cubism or non-objective art is not necessarily what it appears to be on the surface, namely a complete volteface from the most careful service of reality to the boldest disregard of it. The extreme concreteness of realism as well as the extreme abstractness of some modern art may rather express an identical aloofness from reality in the sense of a feeling for and an understanding of the deeper meaning of life and nature.[15]

[14] In scientific and philosophical theory 'decorative' systems are sometimes constructed whose regular, symmetrical form patterns are not an adequate representation of the facts at any level of approximation. ("*. . . et comme dans notre esprit se forment symétriquement les hypothèses,*" Paul Valéry.)

[15] The interest in the perspectively deformed 'retinal' projections as well as in the elementary buildingstones of perceptual comprehension may be compared with our modern emphasis on psychology, *i.e.*, on the subjective reaction to external reality. One of the sources

As a final example may be cited the pictorial creations of certain psychotics, and particularly schizophrenics. The detachment from reality which is characteristic of the psychological state of these patients again produces the symptom of form patterns insufficiently controlled by the representational subject and therefore abandoned to the play of perceptual organization. The pictures of these psychotics are described as highly abstract, stylized, geometrical, ornamental, etc. (2, 3). One gets the impression that the receptor mechanism is organizing in a void. Frequently the disease even interferes with the capacity for formal integration so that a chaotic agglomeration of representational remnants and other elementary forms results.

of this emphasis is a weakened interest in external reality itself. In this connection one may also recall a tendency of post-Renaissance art to stress the process of creation, the strokes of the brush, the imprints of the modelling chisel or finger, the appreciation of sketchy drawings as works of art in their own right.

BIBLIOGRAPHY

1. ADAM, L. *Primitive art.* New York: Allen Lane Penguin, 1940.
2. ANASTASI, A., & FOLEY, J. P. A survey of the literature on artistic behavior in the abnormal: II. Approaches and interrelations. *Ann. N. Y. Acad. Sc.*, 1941, 42, 1–112.
3. ——. A survey of the literature on artistic behavior in the abnormal: III. Spontaneous productions. *Psychol. Monogr.*, 1940, 52, nr. 6, 1–71.
4. ARNHEIM, R. *Film.* London: Faber and Faber, 1933.
5. ——. Gestalt and art. *J. Aesthetics & Art Criticism*, 1943, 2, 71–75.
6. BRITSCH, G. *Theorie der bildenden Kunst.* Munich: Bruckmann, 1926.
7. BUNIM, M. S. *Space in medieval painting and the forerunners of perspective.* New York: Columbia, 1940.
8. CANNON, W. B. *The wisdom of the body.* New York: Norton, 1932.
9. COOMARASWAMY, A. Ornament. *Art Bull.*, 1939, 21, 375–382.
10. ——. *Why exhibit works of art?* London: Luzac, 1943.
11. GELLERMANN, L. W. Form discrimination in chimpanzees and two-year-old children. *J. genet. Psychol.*, 1933, 42, 3–27.
12. GOLDSTEIN, K. *Human nature.* Cambridge: Harvard, 1940.
13. GOLDWATER, R. Art and nature in the 19th century. *Magaz. Art*, 1945, 38, 104–111.
14. GOODENOUGH, F. L. *Measurement of intelligence by drawings.* Yonkers: World Book, 1926.
15. KAINZ, F. Gestaltgesetzlichkeit und Ornamententwicklung. *Z. angew. Psychol.*, 1927, 28, 267–327.
16. KOFFKA, K. *Zur Analyse der Vorstellungen und ihrer Gesetze.* Leipzig, 1912.
17. ——. *Principles of Gestalt psychology.* New York: Harcourt, Brace, 1935.
18. KÖHLER, W. *The place of value in a world of facts.* New York: Liveright, 1938.
19. KÜHN, H. *Die Kunst der Primitiven.* Munich: Delphin, 1923.
20. LÖWENFELD, V. *The nature of creative activity.* New York: Harcourt, Brace, 1939.
21. ——. Tests for visual and haptical attitudes. *Amer. J. Psychol.*, 1945, 58, 100–111.
22. SCHAEFER-SIMMERN, H., & SARASON, S. B. Therapeutic implications of artistic activity. *Amer. J. ment. Defic.*, 1944, 49, 185–196.
23. VERWORN, M. *Zur Psychologie der primitiven Kunst.* Jena: Fischer, 1917.
24. WERTHEIMER, M. Untersuchungen zur Lehre von der Gestalt, II. *Psychol. Forsch.*, 1923, 4, 301–350.
25. ——. Laws of organization in perceptual forms. In *A sourcebook of Gestalt psychology* (W. D. Ellis, Ed.). New York: Harcourt, Brace, 1939. Pp. 71–88.
26. WOODWORTH, R. S. *Experimental psychology.* New York: Holt, 1939.
27. *Manafi al-Hayawan (Description of animals).* Persian manuscript, 13th century. New York: Pierpont Morgan Library, Ms. 500.

A THEORETICAL DERIVATION OF LATENT LEARNING[1]

BY JOHN P. SEWARD

University of California at Los Angeles

I. Problem

In 1929 Blodgett reported from Tolman's laboratory the results of an important series of experiments on maze learning (6). In these experiments a control group of rats found food in the goal box after every run; an experimental group found food in the goal box only after a number of unrewarded runs. The error curve of the experimental group typically showed little decline during the unrewarded trials. Between the first rewarded trial and the next, however, the curve fell steeply almost to the level of the control group, and the amount of this drop exceeded the greatest single fall in the control curve. This phenomenon, later confirmed by Tolman and Honzik (43), was taken as evidence of 'latent learning.' The concept has been validated by a variety of procedures (10, 12, 13, 18, 19, 46).

In the first of his experiments Blodgett used a T maze containing six blind alleys. Recently Reynolds (37) repeated this experiment with results that called the earlier finding into question. He found no evidence of latent learning; his experimental groups showed a decrease of errors before food was introduced and no acceleration thereafter. His data suggest that the steep drops in the earlier curves may have been enhanced by chance fluctuations. Moreover he found that all groups made a larger proportion of incomplete entrances into blinds in successive trials and held that this fact reduced the significance of any sudden improvement that might occur late in learning. Blodgett performed one experiment, however, to which the latter criticism does not apply. His maze *C* provided a single choice between a longer and a shorter path to the goal. Here there were no blinds to be eliminated, yet the effect of introducing food was as striking in this case as in any other.

Blodgett's finding is important because it has come to occupy a crucial position in the controversy between 'field' theories of learning, as formulated chiefly by Tolman and Lewin, and the *S-R* theories of Hull, Guthrie, and Thorndike. It holds this position because, although many of the differences between the two schools may reduce to a matter of terminology, here is a point at which experimental predictions are definitely at variance. So we find White (48) basing his defense of Tolman and Lewin almost exclusively on latent learning. Gestalt supporters invariably fall back on the phenomenon as final evidence of the soundness of their views. And so far, it must be admitted, their challenge has not received a satisfactory answer.

At first the trouble with Hull's theory appeared to be its failure to distinguish between learning and performance—a minimum requirement for an account of latent learning. Later this defect was corrected. Learning is now represented by the

[1] The content of this article was presented in part to the Eastern Psychological Association at Fordham University, April 26, 1946. The writer is indebted to Professors C. L, Hull, K. F. Muenzinger and E. C. Tolman. for reading and criticizing the manuscript.

construct of *habit strength;* performance is directly related to *effective reaction potential*, most simply defined as the product of effective habit strength and *drive* (**23**, p. 253). That is, Hull explicitly recognizes the role of motivation in the *use* of habits. But this improvement was not enough. Hull's difficulty with latent learning arises from two main features of his theory: (1) To be learned a response must be *reinforced* by the reduction of a need. (2) Since habit strength grows by successive increments, sudden shifts in level of performance can be produced only by changing the strength of the other factor, drive. In Blodgett's experiments before the introduction of reward there was no obvious need reduction to reinforce learning; after it there was no change in drive to bring about improved performance.

It is conceivable that the real bone of contention lies, not between Gestalt and *S-R* psychologists, but rather between those who insist on reinforcement as a condition of learning and those who do not. We turn therefore to Guthrie (**17**), who stands for an *S-R* theory of learning *without* reinforcement. And at first sight Guthrie seems to have avoided both of the difficulties mentioned above. In Guthrie's view conditioning occurs whenever a stimulus and a response occur together; furthermore, it is complete in one trial. He thus provides the *possibility* that Blodgett's experimental animals would perform as they did. At the same time he runs the risk of proving too much. For if the experimental rats can learn in one trial, why do the control rats learn only in the course of many trials? And if Guthrie explains the gradual learning of the control rats by multiple conditioning, how does he explain the sudden learning of the others? So far he has not made clear the basis for a differential prediction in this case.

By contrast, Tolman and Lewin take latent learning in their respective strides. For Tolman (**41**), we learn by observing the consequences of our acts, thereby acquiring *expectations* that certain acts will lead to certain consequences. What an animal learns depends on what he perceives. What he does, however, depends not only on what he has learned but on how he is motivated at the moment. Thus a rat learns a maze by running it, but he will reveal his knowledge only when his *appetite* is aroused by an object appropriate to his *demand* and when the maze is seen as a path to that object (**42**). Lewin's field theory of learning and motivation, couched in terms of *cognitive structure* and *valence*, leads to an essentially similar account (**31**). In fact, Buxton (**10**) has formally deduced the characteristics of latent learning as he found them from a set of field-theoretical assumptions.

For these theorists, then, latent learning presents no special problem; the experiment simply provides a demonstration of the perceptual nature of all learning. But in sketching a theory broad enough to cover a wide array of facts they have sacrificed something in precision. For all of its limitations, Hull's approach stands alone as an attempt to state the *quantitative* relations of his constructs to experimental factors on the one hand and to behavioral measures on the other. Whether or not such statements can eventually be made about the concepts of field theory, the fact remains that so far the *S-R* type of analysis has yielded more readily to mathematical treatment. This important advantage justifies an attempt to extend the usefulness of Hull's methodology as far as possible.

The problem of the present paper

may therefore be stated as follows: *taking Hull's principles as our point of departure, to introduce such changes and additions as may make possible a quantitative prediction of behavior in a typical latent learning experiment.* If the method is sound, its results should prove useful for other predictions as well. They should also help to remove one source of cleavage between opposing theories of learning.[2]

II. POSTULATES

The first obstacle to be dealt with is the dependence of learning on reinforcement. Two alternatives suggest themselves. One, the more drastic, is to abandon the principle altogether. The other is to follow those writers who point out that other needs besides hunger are reduced by maze exploration, such as an investigatory drive, or, if that notion is too McDougallian, a fear drive. Anticipatory responses to the various maze parts might thus be conditioned to the choice points according to the *goal gradient* (**24**). Accepting this argument for the moment, let us turn to the second obstacle, the impossibility of a sudden shift in performance level as long as drive is constant. Again there is a drastic remedy: to expand the concept of drive in such a way as to make it partly a function of incentive.[3] But again we hesitate to take this step before it is proved necessary. As things stand we could assume in the unrewarded experimental rats a fractional antedating food reaction (**21**) aroused by the hunger drive stimulus and contributing part of the stimulus complex already conditioned to maze running. On this assumption, when food is found in the goal box the eating response is powerfully reinforced and its fractional antedating component, carried forward to the several choice points, throws its weight in favor of the correct turns. But aside from its over-simplification and figurative language, this whole approach runs into a more serious difficulty. The latent-learning experiments imply that a maze is equally well learned with or without food; if so, food-reinforcement is no more effective than fear-reinforcement or exploration-reinforcement. It follows that some other response in the goal box—*e.g.*, exploring a recess behind a newly opened door—should have an effect on errors comparable with the response to food. Such a consequence seems most unlikely.

The facts thus demand a more radical revision of certain of Hull's principles. Specifically they have led to a restatement of one postulate, the addition of two more, and a reworking of the drive concept. These changes, together with the reasons for their adoption, will now be presented within the general framework of Hull's system.

Postulate 4, summarizing the essential conditions of learning, may be considered the keystone of the whole structure. Hull's statement, somewhat abridged, is as follows (**23**, p. 178):

"Whenever an effector activity and a receptor activity occur in close temporal contiguity . . . closely associated with the diminution of a need . . . there will result an increment to a tendency for that afferent impulse . . . to evoke that reaction. . . . Habit strength is a simple positive growth function of the number of reinforcements. The upper limit . . . is the product of (1) a positive growth

[2] Another way to reach the same goal might be to try to quantify Tolman or Lewin. I suspect that the more quantitative these systems became, the more they would resemble the S-R formulas.

[3] Crespi (**11**) has already embodied this idea in a theory of 'incentive motivation' to explain the effects of varying the amount of 'reinforcement' on performance.

function of the magnitude of need reduction . . .; (2) a negative function of the delay in reinforcement; and (3) a negative growth function of the degree of asynchronism of S and R . . . ."

How can this postulate be so revised as to afford a prediction of Blodgett's finding with maze C?

As we have seen, the latent-learning experiments suggest that rats can learn the layout of a maze with or without food in the goal box. Secondly, they suggest that the effect of food is fully exerted on the very next trial. The second finding may be partly accounted for if we separate the learning of the experimental rats into two parts: (1) learning the locations of the various maze parts, *i.e.*, associating right and left turns with differential anticipatory responses; (2) associating the goal box with food. The first learning process is apparently gradual, the second abrupt. The difference between them cannot be attributed to a peculiarity of the food response, since the error curve of hungry rewarded rats is typically graded. The most plausible difference is that the first process involves a time interval between stimulus and response, the second, none. These considerations suggest the following revision of postulate 4:[4]

Postulate 4 (revised):—A stimulus (S) followed by a response (R) acquires an increment of conditioning to that R. When R follows S immediately conditioning is complete in one concurrence. When it is delayed habit strength ($_sH_R$) is a positive growth function of the number of concurrences; its upper limit is a negative growth function of the time interval between S and R, while the fractional increment per trial is also a negative function of the time of delay.[5]

As Skinner has pointed out (**40**), certain responses, called by him *respondents*, are innately correlated with specific stimuli, while others, called *operants*, are not. Respondents vary in magnitude with the intensity of their stimuli. But there is evidence that the magnitude of an unconditioned response is a factor determining the strength of conditioning (**20**). The conditioning of respondents therefore constitutes a special case and suggests the following addition to the revised postulate 4:

In the conditioning of a *respondent* the upper limit of $_sH_R$ is a positive growth function of the intensity of the unconditioned stimulus (Su).

Our present interest in this provision lies in the probability that consummatory reactions, such as eating, should be classed with respondents rather than operants, since either innately or after brief learning they seem to vary in strength according to the amount or quality of the incentive. In order to deal with these reactions the above provision could be paraphrased as follows:

In the conditioning of a *consummatory reaction* the upper limit of $_sH_R$ is a positive growth function of the *amount* of the *goal object*.

The above revision of postulate 4 enables us to predict that unrewarded rats at a choice point will gradually learn to make anticipatory responses to the goal box, the rate of learning being determined by the time it takes to get from one place to the other. We can also predict that one rewarded trial will be enough to condition food responses to the stimuli operating in

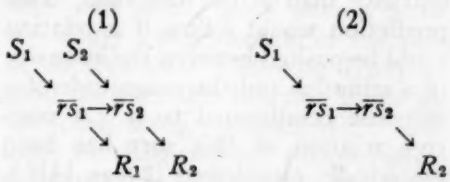
[4] The precise terminology of the original is here relinquished in the interest of simplicity.

[5] The first two sentences are obviously taken almost bodily from Guthrie (**17**). As Mrs. E. S. Lisansky kindly pointed out to me, the implications of the last part could probably also be derived from Guthrie's postulates.

the goal box. It is our underlying thesis that the striking change in the rats' performance after the introduction of food is due to the arousal of anticipatory food reactions at the choice point. But these reactions must be *differentially* aroused *on the very next trial* by stimuli encountered on entering the long and short paths, respectively. This could happen if the food reactions were aroused by the anticipatory goal-box reactions, and these in turn were more strongly conditioned to the short-path entrance than to the long one. Our theory must therefore provide a mechanism that will make such a prediction possible.

In earlier papers (**21**, **22**) Hull made frequent use of 'fractional anticipatory reactions' and 'pure-stimulus' acts but barely mentioned them in the *Principles* (**23**). We are left with no clear idea of the relation between these concepts and the responses dealt with in his postulates. Does a partial reaction have the same status as a full-fledged response? If so, to which does postulate 11 refer: the postulate which describes the reaction threshold (**23**, p. 344)? Does an overt response have one threshold and its fractional component another? Such a situation is quite conceivable; in fact, a whole series of thresholds may be envisaged depending on the size of response unit chosen. It would thus be possible to work out the entire theory on the basis of reaction segments and the proprioceptive stimuli they produce. The argument runs into difficulties when we give this mechanism an essential role in response evocation and at the same time give it the status of a response that must itself be evoked. If, as will be developed later, the fractional antedating reaction is one determinant of *drive*, it seems a bit illogical to make drive a necessary condition of its occurrence. At any rate, in practice the procedure constantly threatens to bog down through its own unwieldiness.

As a way of avoiding this complication I should like to propose the concept of the *surrogate response*. This construct may be thought of as a kind of short-circuiting device interposed between an external stimulus and its explicit response. As its name implies, it stands for some phase of the original *S-R* connection; either certain properties of *S*, in which case it may be called a *perceptual response*, or certain properties of *R*, in which case it may be called an *implicit response*, or both. This process involves no appeal to mysticism, since the proposed mechanism is already a part of the behavior segment for which it stands. Physiologically it is located in the central connections of the nervous system. Its essential feature is that it combines the characteristics of *R* and *S*; *i.e.*, as *R* it can be conditioned to other afferent impulses, but it can in turn serve as *S* to which other *R*s may be conditioned. Thus, if we denote the surrogate response by the symbol $\overline{rs}$, its role in conditioning may be diagramed as follows:



The importance of such a feature in the mediation of habit sequences may readily be appreciated. Hull has amply demonstrated it already, using the concept of the response-produced stimulus (**25**). By placing the mechanism in the central connections rather than the periphery we have simply attempted to increase its usefulness

by freeing it from the restrictions governing response evocation.[6]

Conceivably the conditions of habit formation could be entirely restated in terms of connections between $\overline{rs}$'s. But for our present purpose it will be enough to introduce the concept and indicate its usefulness in the problem at hand. We shall therefore incorporate it in a postulate which, to distinguish it from Hull's original sixteen, we may call postulate A.

Postulate A:—Each S that activates an organism's receptors evokes a *surrogate response* ($\overline{rs}$) in the neural centers capable of being conditioned as a response to concurrent Ss and as a stimulus to concurrent Rs in accordance with postulate 4 (revised). $\overline{rs}$ can be evoked by a conditioned stimulus independently of drive; its magnitude, and consequent intensity as a stimulus, are a linear function of effective habit strength.

Postulate A enables us to predict that surrogate responses to the goal box will come to be evoked more strongly by short-path than by long-path stimuli at the choice point. We can also predict that surrogate food reactions will be conditioned to the goal-box $\overline{rs}$. It is still necessary to ensure that the $\overline{rs}$ to *food* will be more strongly aroused at the short-path entrance than at the long one. This prediction would follow if a relation could be posited between the intensity of a stimulus and the magnitude of a response conditioned to it. A positive relation of this sort has been empirically established (**20**, p. 141f.). In terms of Hull's system it may be conveniently derived through the intervening variable of *effective habit strength* ($_s\bar{H}_R$). Hull uses this concept in deducing the phenomenon of stimulus generalization. According to postulate 5 (**23**, p. 199), $_s\bar{H}_R$ starts from $_sH_R$ at the point of reinforcement and decreases as a negative growth function of the difference between the S at that point and the S evoking the R. What we need is a second postulate making $_s\bar{H}_R$ also dependent on the absolute intensity of the R-evoking S. The several R-characteristics (amplitude, latency, frequency) may then be related to $_s\bar{H}_R$ by way of reaction potential, as Hull has shown.

The form of the function relating $_s\bar{H}_R$ to S-intensity is a matter for conjecture at present. If S is a *peripheral* stimulus measured in physical units a Fechnerian formula is suggested, although consistency with the rest of Hull's system calls for a positive growth function. If S refers to a *central* afferent discharge, such as $\overline{rs}$, however, a linear relationship seems more likely.[7] With these two possibilities in mind, we may tentatively formulate postulate B as follows:

Postulate B:—Effective habit strength ($_s\bar{H}_R$) is a positive growth function of the intensity of a peripheral response-evoking S, in which the fractional increment is proportional to $_sH_R$; in the case of a central R-evoking S, $_s\bar{H}_R$ is an increasing linear function of stimulus intensity, the slope of which is proportional to $_sH_R$.

Having dealt with the mechanics of latent learning we may now turn to the problem of response evocation. Hull's solution to this problem is

[6] The *surrogate response* is not only a central counterpart of Hull's 'pure-stimulus act' but provides a basis in terms of S-R for Tolman's 'sign-Gestalt' (**41**) and Krechevsky's 'hypothesis' (**29**). Behaviorists will undoubtedly criticize it as 'mentalistic.' As with all 'intervening variables' (**26**), it can be freed from this charge only by being clearly defined in terms of observable antecedents and consequences.

[7] At this point the advantage of a more thorough-going use of the intervening variable $\overline{rs}$ becomes apparent. It would enable us to set up $_s\bar{H}_{\overline{rs}}$ as a positive growth function of S and $_{\overline{rs}}\bar{H}_R$ as a linear function of $_s\bar{H}_{\overline{rs}}$.

found in postulate 7 (**23**, p. 253), where he defines reaction potentiality as the product of an increasing function of effective habit strength multiplied by an increasing function of drive (D). For Hull, primary drive is strictly a symbolic construct, but he suggests that its physiological basis may be a certain chemical condition of the blood, varying with the need in question, which exerts a twofold effect: (1) In some needs it produces a characteristic drive stimulus that plays a part in habit formation. (2) It lowers the resistance of neural structures to the impulses involved in learned reactions, thus 'sensitizing habit strength into reaction potentiality' (**23**, p. 253).

As indicated above, this concept of drive is too simple to account for the behavior observed in the latent-learning experiments. The mere presence of surrogate reactions is apparently not enough to ensure elimination of excess distance; otherwise such reactions to the empty goal box itself should produce marked improvement.[8] The blood-stream condition was relatively unchanged from trial to trial. How, then, can a sudden drop in errors be explained?

The common-sense notion, given academic sanction by Tolman, is that the anticipation of food motivates the hungry rat to make the best use of his acquired maze orientation. But this notion sounds surprisingly like 'sensitizing habit strength into reaction potentiality.' It suggests the solution here proposed; namely, in the formula for reaction potential, to enter the strength of the surrogate food reaction under D rather than ${}_{S}\bar{H}_{R}$.

To justify such a procedure requires a more detailed analysis of drive. On the physiological level we need a neural rather than a strictly chemical mechanism. Surgical experiments, particularly in connection with sex (**5**), rage (**4, 47**), and general excitability (**36**), point to the importance of the brainstem. They lend support to the view that drive may be correlated with the activation of subcortical centers and that these serve the twofold function of innervating certain preferential responses (*e.g.*, eating, drinking, copulating, fighting) and of facilitating a variety of auxiliary cortical activities (**34**). Strength of drive thus varies directly with the amount of excitation of a given center in the thalamus, hypothalamus, or midbrain. Our immediate task is to identify the sources of excitation and to relate them to observable conditions. Each drive requires separate analysis and may be found to demand a special set of postulates. I shall not attempt this task in a formal way, but shall make some tentative suggestions toward a quantitative calculation of the strength of the food drive.

A preliminary survey suggests that four factors should be considered: (1) The presence or absence of certain chemicals in the blood stream is undoubtedly some function of the time of deprivation. Following Hull, we shall consider this function linear for the time being. Unlike Hull, however, we shall contend that its sensitizing effect is limited primarily to the neural mechanism of the food drive itself.[9] (2) A second factor is what Hull refers to as the *drive stimulus* (S_D), in this case taking the form of neural discharges from the contractions of the empty stomach. The strength of these contractions is also,

[8] That *some* improvement does take place when excess distance is in the form of blind alleys has been well established (**2, 6, 19, 37, 43, 45, 46, 49**).

[9] Evidence for a selective action of chemicals on reflex centers is fragmentary but fairly impressive (**38**).

at least for a time, some positive function of the deprivation interval. (3) Since stomach contractions are intermittent, we must presuppose some other source of excitation to account for the continuity of hunger. The hunger center is presumably subject to a small, relatively constant amount of stimulation (S_D) from other organic processes in the body. (4) There are probably exteroceptive stimuli (S_G)—*e.g.*, tastes, smells, mouth contacts—with unconditioned access to the sensitized hunger center and thereby to the consummatory responses of sucking, biting, chewing, or swallowing.

But before drive strength can be made a mathematical function of these variables they must be expressed in comparable units and suitably combined. For this purpose a centigrade scale may be set up, similar to those of Hull, to measure the *reflex strength* of any stimulus to excite the drive mechanism ($_sU_D$). Reflex strength, like $_s\bar{H}_R$, is to be considered an increasing function of stimulus intensity, logarithmic or exponential if S is peripheral, linear if it is central. Factors (2), (3), and (4) above are thus taken care of. Number (1), the chemical factor, can best be treated as Hull has treated drive as a whole; *i.e.*, expressed in units on a scale of 100 and used as a multiplier with each of the other three factors in turn. Finally, a method of combining these three products is available in Hull's major corollary I (**23**, p. 199), which supposes that effective habit tendencies to a given reaction summate according to a positive growth function. To write an equation for the strength of the food drive, we need only extend this principle of 'physiological summation' to the products representing drive reaction potentials.

Space forbids the detailed setting forth of this equation here. It will be readily seen, however, that for the latent-learning experiment the critical factor in that equation is $_{sG}U_D$, the *reflex strength* of goal stimuli to arouse the food drive. For this factor varies with the intensity of S_G and thus stands for the motivating power of the incentive in the situation. On the critical trial of an experimental rat the intensity of S_G at the choice point will depend on the degree of arousal of $\overline{rs}_G$, a value determined, as we have seen, by the effective habit strength linking it to the surrogate goal-box reaction. The more strongly the latter reaction is aroused by the stimuli coming from one direction or the other, the stronger will be the resulting drive and the greater the likelihood of the rat's moving in that direction. Meanwhile it will be found convenient to embody the essential features of the above analysis in the following brief statement:

Postulate C:—The strength of the food drive (D_F) is an increasing function of the number of hours of deprivation and of the intensity of *Ss* (tastes, smells, mouth contacts) involved in the consummatory eating *Rs*.

III. PROOF

If our reasoning is correct we should now be able to predict, with the aid of the above revisions and extensions of Hull's postulates, the essential facts of latent learning. Let us choose, as the simplest example, Blodgett's experiment with maze *C* and attempt a somewhat formal derivation of his findings. A drawing of maze *C* is here reproduced in Fig. 1. The animals were started at *S* and allowed to enter either *A* or *B*, about an equal number of rats running to each goal box. Blodgett gave a control group of 23 rats one trial a day for 16 days; on each trial they found food in the goal box and were permitted to eat for two minutes. The experimental group of

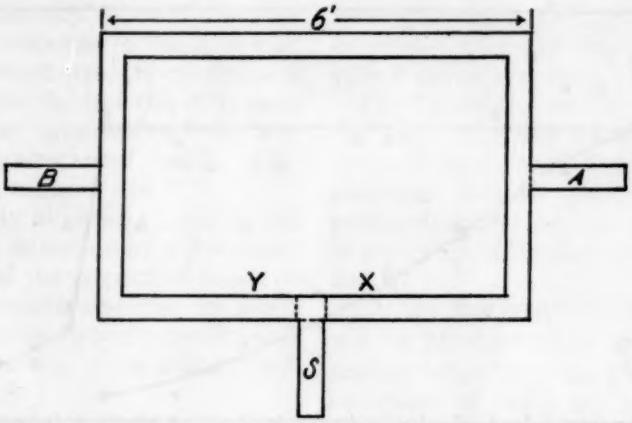


FIG. 1. Blodgett's maze *C* (drawn from figure appearing in [6]). *S* is the starting box, *A* and *B* are food boxes. Only one food box was open for each rat.

21 rats was given one trial a day for 20 days. The first 15 days they found the goal box empty; on the sixteenth and all later trials they were fed in the goal box just as the control group had been.

Blodgett reported his results in terms of the number of long-path choices per trial in each group. The data, expressed as percentages, are represented by the crosses and triangles in Fig. 2. After the third day the control scores declined fairly regularly until at the end of the series not more than one or two rats took the long path. The experimental group, on the other hand, showed no clear trend for the first 16 days. Between the 16th and 17th trials the number of rats taking the long path dropped from 11 to 4; the largest drop by the controls was from 13 on trial 3 to 9 on trial 4. On each of the last three trials only two experimental rats chose the long path. It is with the experimental group that we are here concerned, and our first task will be to test the adequacy of the preceding argument on a qualitative level by casting it in the form of a 'geometrical' proof.

In addition to postulates 4 (revised), A, B, and C, above, the following assumptions, largely borrowed from Hull, are needed:

Hull's postulate 7 (abridged from **23**, p. 253):—Reaction potentiality ($_sE_R$) (is) a product obtained by multiplying an increasing function of $_s\bar{H}_R$ by an increasing function of D.

Hull's postulate 10 (abridged from **23**, p. 319):—Associated with every $_sE_R$ there exists an inhibitory potentiality ($_sO_R$) which oscillates in amount from instant to instant according to the normal 'law' of chance. . . . The amount of $_sO_R$ associated with the several habits of a given organism at a particular instant is uncorrelated.

Corollary A (from postulate 10):—Momentary effective reaction potential ($_s\dot{E}_R$) fluctuates from one organism to another on a given trial in the same manner as it oscillates within a single organism from moment to moment.

Hull's postulate 16 (**23**, p. 344):—When the $_sE_R$'s to two or more incompatible *Rs* occur in an organism at the same time, only the R whose $_s\dot{\bar{E}}_R$ is greatest will be evoked.

Given:—the experimental conditions described above. For convenience

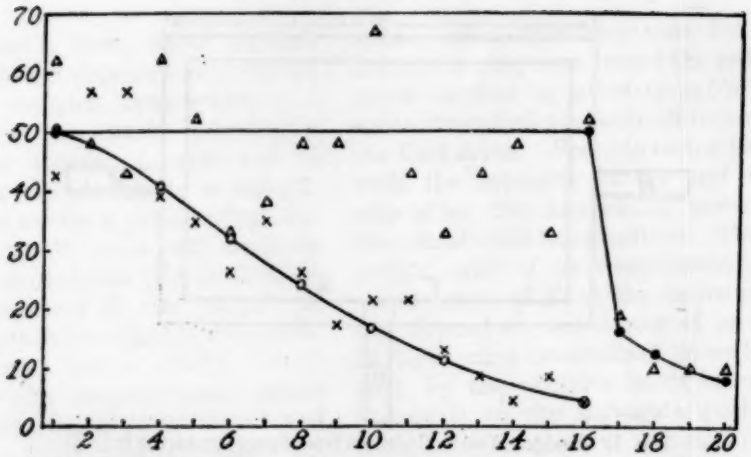


FIG. 2. Percentages of long-path choices on successive trials by Blodgett's rats as empirically obtained and theoretically derived. Crosses and triangles represent empirical data of control and experimental groups, respectively. Hollow and solid circles represent corresponding predictions, derived as explained in text.

we shall consider A the goal box, making X the short path and Y the long one (Fig. 1). The stimuli encountered by the rat on turning right at the choice point will be called S_X; those encountered on turning left, S_Y; those in the goal box, S_A; those pertaining to food, S_G.

To prove:—that whereas during unrewarded trials the experimental group (E) will make about the same number of X and Y choices, on the next trial after the first rewarded trial the number of Y choices will be decreased by an amount greater than the greatest single decrease in the control group (C).

Proof:—1. The percentage of rats choosing path Y will vary inversely with the difference in reaction potentials in favor of path X, according to the following equation:

$$P_Y = 50 - f\left(\frac{{}_{S_X}E_{R_X} - {}_{S_Y}E_{R_Y}}{\sigma_0\sqrt{2}}\right),$$

where f refers to the integration of the normal probability function and σ_0, the standard deviation of oscillation, is assumed to be the same for the two habits. [By corollary A (from postulate 10) and postulate 16.]

2. Since simultaneous conditioning is complete in one trial, after the first choice of either X or Y there will be no further increase of ${}_sH_R$; *i.e.*, when $N > 0$, ${}_{S_X}H_{R_X} = {}_{S_Y}H_{R_Y} = M$, where N is the number of preceding trials and M is the limit of ${}_sH_R$. [By postulate 4, revised.]

3. In group E, since hunger is kept constant [by experimental conditions], and since ${}_sH_R$ is here interchangeable with ${}_s\bar{H}_R$, during unrewarded trials the Y choices should approximate 50 per cent.[10] [By steps 1 and 2 and postulate 7.]

[10] There are further implicit assumptions (see postulate 3 [23, p. 66]) behind the entire proof; that before the present conditioning there is a tendency, learned or unlearned, to respond positively to X and Y, and that on the average the tendencies in both directions are of equal strength and well within oscillation range of the maximum effective reaction potential in the absence of incentive. Otherwise a rat that chose Y on the first trial might be expected to choose Y on every trial thereafter.

4. After one run in each direction a surrogate response to the goal box, $\overline{rs}_A$, will be more strongly conditioned to S_X than to S_Y, and this difference will increase progressively in the course of unrewarded trials. [By postulates 4, revised, and A.]

5. Similarly in group C, and to the same extent, as measured in fractional increments of the respective limits of ${}_sH_R$, a surrogate response to food, $\overline{rs}_G$, will be more strongly conditioned to S_X than to S_Y. [By postulates 4 revised, and A.]

6. As measured in these units, after 16 trials the total difference between ${}_{sX}H\overline{rs}_A$ and ${}_{sY}H\overline{rs}_A$ in group E is thus greater than the increment of difference between ${}_{sX}H\overline{rs}_G$ and ${}_{sY}H\overline{rs}_G$ in group C after any single trial. [By steps 4 and 5.]

7. On the first rewarded (16th) trial of group E, $\overline{rs}_G$ will be completely conditioned to $\overline{rs}_A$. [By postulate A.]

8. On trial 17 $\overline{rs}_A$ will be more strongly aroused at the choice point by S_X than by S_Y. [By step 4 and postulates A and B.]

9. On trial 17 effective habit strength between S_X and $\overline{rs}_G({}_{sX}\bar{H}\overline{rs}_A\bar{H}\overline{rs}_G)$ will be stronger than between S_Y and $\overline{rs}_G({}_{sY}\bar{H}\overline{rs}_A\bar{H}\overline{rs}_G)$ [by steps 7 and 8 and postulate B], and this difference will be greater than the corresponding increment of difference in group C after any single trial[11] [by step 6].

10. Thus, on trial 17, $\overline{rs}_G$ will be more strongly aroused at the choice point by S_X than by S_Y, and the difference will be greater than the corresponding increment of difference in group C after any single trial. [By step 9 and postulate A.]

11. Therefore, on the same trial, the food drive will be more strongly aroused by S_X than by S_Y, and the difference will be greater than the greatest single increment of difference in group C. [By step 10 and postulate C.]

12. On this and later trials ${}_{sX}E_{RX}$ will be stronger than ${}_{sY}E_{RY}$ by an amount larger than the greatest single increment of difference in group C. [By steps 2 and 11 and postulate 7.]

13. Consequently, from trial 16 to trial 17 the percentage of Y choices in group E will decrease more than the greatest single decrease in group C. [By steps 1, 3, and 12.]

Q.E.D.

The above proof is quantitative only in the general sense of more or less. It is possible to put the theory to a more exacting test. By the choice of appropriate constants we should be able to derive results approximating those that Blodgett actually obtained. Such an attempt has been made, with the result shown in figure 2.[12] As already explained, the crosses represent the percentages of the control group that chose the Y route in successive trials. The triangles stand for the corresponding percentages of the experimental group. The hollow circles represent the percentages of the control group as theoretically derived. They are joined by a free-hand curve which has been extrapolated on the assumption of an initial value of 50 per cent. The solid circles stand for the predicted percentages of the experimental group. From trials 1 to 16 the theory calls

[11] Here, since the limits of ${}_sH_R$ are the same, the differences in groups E and C can be expressed in the same units, giving the statement a wide range of validity. For a demonstration of the mathematical basis of this argument the reader is referred to footnote 12. He will find that step 9 holds good as long as the constants of proportionality in postulates A and B stay above certain (empirically determined) limits.

[12] The author will be glad to send on request a mathematical statement of all postulates and a detailed account of how the values of the plotted points were obtained.

for a straight line parallel to the base, a sharp drop from the first rewarded trial to the second, and a gradual decline thereafter; the points have been joined accordingly.

These curves, it should be explained, are 'theoretical' only to a limited degree. Most of the constants were arbitrarily selected to fit the data. One equation, representing the fractional increment of habit strength per trial as a function of the interval between S and R, was selected simply because it gave a better fit that the negative growth function originally tried. For the number of choices of X or Y the actual means of Blodgett's groups were used; a strictly deductive procedure would have involved calculating these numbers trial by trial from the beginning. In spite of these defects the curves demonstrate that by means of the above postulates, and with sufficient latitude in the choice of numerical values, it is possible to approximate Blodgett's results. To that extent, at least, the postulates are verified.

Exception may be taken, however, to the closeness of fit, especially in the experimental group. Despite the wide scattering of the first 16 scores, the best-fitting straight line would probably have a slight downward slope. A weak preference for the shorter route was apparently active even before any obvious reward was introduced. A similar trend appears in other published curves of unrewarded or satiated maze running (see footnote 8), as well as in unpublished data of the writer's on the latency of bar pressing by satiated rats. Evidently there is not only *learning* in the absence of conspicuous reinforcement, which the present theory predicts, but also some 'improvement' of *performance*, which our theory does not predict. Failure to account for this finding must be recognized as a defect in the formulation here proposed.[13]

IV. FURTHER IMPLICATIONS

A theory, if at all useful, should contain verifiable implications beyond the events it was designed to predict. Examining the above account of latent learning we may ask two general questions: (A) What further implications does it carry for observations within the framework of the latent learning experiment? (B) What are its implications for learning in general? A few suggestions in reply to each question may be in place.

(A) Despite the steepness of the drop in Y choices after trial 16 the experimental curve does not actually reach the level of the control on the next trial. The gap can be traced to two factors: (1) In the experimental group, but not in the control, a 'reduction factor' (see footnote 12) had to be introduced in computing the strength of the surrogate goal reaction because it was aroused indirectly by way of $\overline{rs}_A$, a process presumably involving a certain loss of efficiency. Any method, then, of eliminating the 'middle man,' $\overline{rs}_A$, should tend to close the gap between the two groups on the critical, post-reward trial. One way to do this would be to satiate the experimental group and put food in the goal box on every trial. The prediction would be that when they were first made hungry they would approach the controls' performance more closely than in Blodgett's experiment.

(2) The second factor keeping the two curves apart was the difference between the groups in the relative numbers of X and Y choices they made. In the experimental group for the first 16 trials N_X was about equal

[13] I believe the defect could be remedied without revising the theory in any essential way. But it cannot be done here.

to N_Y, while for the controls N_X became increasingly greater. The critical difference for the control group, $_{S_X}\bar{H}_{\overline{rs}_G} - {}_{S_Y}\bar{H}_{\overline{rs}_G}$, was therefore theoretically greater than the corresponding difference for the experimental group, $_{S_X}\bar{H}_{\overline{rs}_A} - {}_{S_Y}\bar{H}_{\overline{rs}_A}$. It follows that if this inequality of conditions was remedied, preferably by using forced runs for both groups, the difference between their post-reward scores should be reduced.

Again, if we are right in contending that it is the association between $\overline{rs}_A$ and $\overline{rs}_G$ that mediates the experimental animals' sudden improvement, the same result should follow if, instead of rewarding them after a run, we followed Buxton's example (**10**) and placed them directly in *A* for their first feeding.

(B) The significance of the present revision for learning in general springs from three main features, which enable us to account for a number of otherwise baffling phenomena:

(1) It makes learning independent of any process of reinforcement by goal attainment or need reduction. It thus makes provision for such findings as Brogden's 'sensory preconditioning' (**7**) and for the conditioning of responses like the knee jerk and the pupillary reflex, which have created such difficulties for reinforcement theory (see **32**, p. 35). It implies, further, that the conditioning of 'anxiety' is more closely related to the onset of a noxious stimulus than to its termination, a plausible hypothesis that has yet to be established (**30**).

(2) The theory posits one-trial conditioning when *S* and *R* coincide. In so doing it provides for the many instances of sudden habit formation in the literature; *e.g.*, the one-trial learning to press a bar by Skinner's rats (**40**) and the all-or-none adoption of new modes of problem solution by Guthrie's cats (**16**). Even the inner citadel of Gestalt psychology, ***insight***, may yield to a description in terms of associations between simultaneous surrogate reactions.

It should be noted here that when *S* and *R* do *not* coincide our theory makes both the limit of conditioning and the rate of approach to that limit a decreasing function of the time interval between them. We are thus enabled to account for the facts that Hull subsumes under the ***gradient of reinforcement***, the function relating the limit of habit strength to the time elapsing before the occurrence of need reduction. They are here deduced from the gradient of asynchronism between a given stimulus and the goal response.[14]

(3) The consummatory response is made a factor in ***drive***, with the function, not of reinforcing habits, but of activating them and, by activating one habit more strongly than another, of directing behavior. It follows that any stimulus capable of arousing a surrogate goal reaction should facilitate the use of a learned response. We may recognize here one possible mechanism of secondary motivation. As such it may supplement, rather than displace, the theories proposed by Anderson (**1**) and Miller and Dollard (**32**). It differs from them in that it supposes the drive mechanism to be ***indirectly*** conditioned or 'externalized' by way of the surrogate

[14] Unlike Hull's gradient of *S-R* asynchronism, however, ours combines two gradients; one involving *M*, the limit of habit strength, the other involving *F*, the fractional increment per trial. In the most careful attempt yet made to measure the gradient of reinforcement, Perin (**35**) found that practice curves of latency showed the effect of delayed reward both in their asymptotes and in the exponential constants. It must be admitted, however, that the latter effect gave no indication of the negatively accelerated function here assumed.

goal reaction.[15] That the goal response does facilitate performance has been clearly demonstrated by the prefeeding—or rather, predrinking—experiments of Bruce (**8**; see also **33**). Its effect was strikingly shown by Walker (**44**), who found that the extinction curve of bar pressing was significantly heightened by a tone previously made a discriminative stimulus to running down an alley to food. Estes (**15**) got the same result with a tone that had been associated with no particular response other than eating.

The problem of secondary motivation raises many unsolved questions, one of which will serve to conclude our discussion. How specific is the sensitizing effect of a drive? In the last two experiments cited the enhanced response had been associated with the same drive-incentive combination as the enhancing stimulus. Is this a necessary condition? Or will a secondary drive activate an irrelevant habit; a habit, that is, which has been formed in the service of another need or directed toward a different incentive? As with latent learning, interest in the question is enhanced by the fact that Gestalt and *S-R* psychologists show a tendency to take sides, although on closer inspection the difference will probably turn out to be one of degree rather than of opposition. White, for example, in his defense of Tolman and Lewin (**48**), stresses what is at least implicit in their writings, the dependence of behavior on a closely knit pattern of needs and knowledge. A need will function, that is, only when an appropriate goal object is expected. Hull, on the other hand, to whom patterning is not a primary principle (**23**), conceives of a drive as sensitizing all habit structures indiscriminately,[16] and the modifications here proposed have left this aspect of his theory untouched. There is some experimental evidence that the effect of hunger is not confined to food-getting activities. Elliott and Treat (**14**) demonstrated that stomach contractions facilitated the conditioning of shock avoidance in rats. And some such non-specific action must be postulated to account for Anderson's remarkable discovery (**3**) that prefeeding improved the maze running of rats that had never found food in the end box. But Kendler's results on drive interaction (**27**) make it obvious that such simple formulations will not long survive.

V. SUMMARY

An attempt has been made to provide a theoretical basis for the essential facts of latent learning in terms of stimulus and response. Hull's system is used as a framework, but a number of revisions and additions have been introduced, chief of which are the following:

1. In agreement with Guthrie, conditioning is held to be independent of reinforcement and, when *S* and *R* are simultaneous, to be complete in one trial.

2. Rate of conditioning is made a negatively accelerated decreasing function of the time separating *S* and *R*. Hull's gradient of reinforcement thus becomes equivalent to the gradient of asynchronism between *S* and the goal *R*.

[15] It also differs from Anderson's theory in some of its implications. Since, in the case of hunger, the drive mechanism reacts only if chemically sensitized, it should not, as Anderson predicts, be aroused in a satiated animal. Anderson's supporting evidence from maze learning (**2**) has not been confirmed by Siegel (**39**), nor by Koch and Daniel (**28**) and the writer (unpublished) in a bar-pressing situation. A precise definition of *satiation* would be of advantage in future work.

[16] Specificity of response is secured by conditioning to the *drive stimulus* (see **23**, p. 241).

3. Effective habit strength is related not merely to the gradient of stimulus generalization but to the range of 'absolute' stimulus intensities.

4. Response to stimulation is held to involve an intervening variable, the *surrogate response*, conceived of as a central mechanism capable of being conditioned on the afferent side to concurrent *Ss* and on the efferent side to concurrent *Rs*. This construct is offered as (1) a convenient central counterpart of the fractional response-produced stimulus commonly resorted to by *S-R* psychologists, and (2) a mechanism for the 'perceptual learning' of field theory.

5. Drives in general, and the food drive in particular, are held to be mediated by subcortical neural mechanisms under chemical influence. They are also subject to arousal by stimuli involved in consummatory acts; through the conditioning of these acts or their surrogates the importance of goals in the activation and selection of habits is accounted for.

The theory has been given an initial test by using it to deduce the findings in one of Blodgett's experiments.

BIBLIOGRAPHY

1. ANDERSON, E. E. The externalization of drive. I. Theoretical considerations. PSYCHOL. REV., 941, **48**, 204–224.
2. ——. The externalization of drive. III. Maze learning by non-rewarded and by satiated rats. *J. genet. Psychol.*, 1941, **59**, 397–426.
3. ——. The externalization of drive. IV. The effect of pre-feeding on the maze performance of hungry non-rewarded rats. *J. comp. Psychol.*, 1941, **31**, 349–352.
4. BARD, P. Central nervous mechanisms for emotional behavior patterns in animals. *Res. Pub. Ass. nerv. ment. Dis.*, 1939, **19**, 190–218.
5. ——. The hypothalamus and sexual behavior. *Res. Pub. Ass. nerv. ment. Dis.*, 1940, **20**, 551–579.
6. BLODGETT, H. C. The effect of the introduction of reward upon the maze performance of rats. *Univ. Calif. Publ. Psychol.*, 1929, **4**, 113–134.
7. BROGDEN, W. J. Sensory pre-conditioning. *J. exp. Psychol.*, 1939, **25**, 323–332.
8. BRUCE, R. H. The effect of varying the place of the fractional anticipatory-consummatory response upon the rate of acquiring a simple learning problem. *J. genet. Psychol.*, 1943, **63**, 165–175.
9. ——. The effect of removal of reward on the maze performance of rats. *Univ. Calif. Publ. Psychol.*, 1930, **4**, 203–214.
10. BUXTON, C. E. Latent learning and the goal gradient hypothesis. *Contrib. Psychol. Theory*, 1940, **2**, No. 6.
11. CRESPI, L. P. Amount of reinforcement and level of performance. *Psychol. Rev.*, 1944, **51**, 341–357.
12. DAUB, C. T. The effect of doors on latent learning. *J. comp. Psychol.*, 1933, **15**, 49–58.
13. DEISENROTH, C. E., & SPENCE, K. W. An investigation of the problem of latent learning in the white rat. *Psychol. Bull.*, 1941, **38**, 706. Abst.
14. ELLIOTT, M. H., & TREAT, W. C. Hunger contractions and rate of conditioning. *Proc. Nat. Acad. Sci., Wash.*, 1935, **21**, 514–516.
15. ESTES, W. K. Discriminative conditioning. I. A discriminative property of conditioned anticipation. *J. exp. Psychol.*, 1943, **32**, 150–155.
16. GUTHRIE, E. R. Psychological facts and psychological theory. *Psychol. Bull.*, 1946, **43**, 1–20.
17. ——. *The psychology of learning.* New York: Harper, 1935.
18. HANEY, G. W. The effect of familiarity on maze performance of albino rats. *Univ. Calif. Publ Psychol.*, 1931, **4**, 319–333.
19. HERB, F. H. Latent learning—non-reward followed by food in blinds. *J. comp. Psychol.*, 1940, **29**, 247–256.
20. HILGARD, E. R., & MARQUIS, D. G. *Conditioning and learning.* New York: Appleton-Century, 1940.
21. HULL, C. L. Goal attraction and directing ideas conceived as habit phenomena. PSYCHOL. REV., 1931, **38**, 487–506.
22. ——. Knowledge and purpose as habit mechanisms. PSYCHOL. REV., 1930, **37**, 511–525.
23. ——. *Principles of behavior.* New York: Appleton-Century, 1943.
24. ——. The goal-gradient hypothesis and

maze learning. PSYCHOL. REV., 1932, **39**, 25–43.

25. ——. The mechanism of the assembly of behavior segments in novel combinations suitable for problem solution. PSYCHOL. REV., 1935, **42**, 219–245.
26. ——. The problem of intervening variables in molar behavior theory. PSYCHOL. REV., 1943, **50**, 273–291.
27. KENDLER, H. H. Drive interaction. I. Learning as a function of the simultaneous presence of the hunger and thirst drives. *J. exp. Psychol.*, 1945, **35**, 96–109.
28. KOCH, S., & DANIEL, W. J. The effect of satiation on the behavior mediated by a habit of maximum strength. *J. exper. Psychol.*, 1945, **35**, 167–187.
29. KRECHEVSKY, I. 'Hypotheses' in rats. PSYCHOL. REV., 1932, **39**, 516–532.
30. LEEPER, R. Dr. Hull's *Principles of Behavior*. *J. genet. Psychol.*, 1944, **65**, 3–52.
31. LEWIN, K. The conceptual representation and the measurement of psychological forces. *Contrib. Psychol. Theory*, 1938, **1**, No. 4.
32. MILLER, N. E., & DOLLARD, J. *Social learning and imitation*. New Haven: Yale Univ. Press, 1941.
33. MORGAN, C. T., & FIELDS, P. E. The effect of variable preliminary feeding upon the rats' speed of locomotion. *J. comp. Psychol.*, 1938, **26**, 331–348.
34. MURPHY, J. P. & GELLHORN, E. Hypothalamic facilitation of the motor cortex. *Proc. Soc. exp. Biol., N. Y.*, 1945, **58**, 114–116.
35. PERIN, C. T. A quantitative investigation of the delay-of-reinforcement gradient. *J. exp. Psychol.*, 1943, **32**, 37–51.
36. RANSON, S. W. Somnolence caused by hypothalamic lesions in the monkey. *Arch. Neurol. Psychiat.*, 1939, **41**, 1–23.
37. REYNOLDS, B. A repetition of the Blodgett experiment on latent learning. *J. exp. Psychol.*, 1945, **35**, 504–516.
38. SEWARD, J. P. The hormonal induction of behavior. PSYCHOL. REV., 1941, **48**, 302–315.
39. SIEGEL, P. S. Drive shift, a conceptual and experimental analysis. *J. comp. Psychol.*, 1943, **35**, 139–148.
40. SKINNER, B. F. *The behavior of organisms: an experimental analysis*. New York: Appleton-Century, 1938.
41. TOLMAN, E. C. *Purposive behavior in animals and men*. New York: Appleton-Century, 1932.
42. ——. The determiners of behavior at a choice point. PSYCHOL. REV., 1938, **45**, 1–41.
43. ——, & HONZIK, C. H. Introduction and removal of reward, and maze performance in rats. *Univ. Calif. Pub. Psychol.*, 1930, **4**, 257–275.
44. WALKER, K. C. The effect of a discriminative stimulus transferred to a previously unassociated response. *J. exp. Psychol.*, 1942, **31**, 312–321.
45. WALLACE, S. R., JR., & EDWARDS, E. B. Non-rewarded performance in a linear maze. *Psychol. Bull.*, 1942, **39**, 584. Abst.
46. ——, BLACKWELL, M. G., JR., & JENKINS, I. Prereward and postreward performance in the "latent learning" of an elevated maze. *Psychol. Bull.*, 1941, **38**, 694. Abst.
47. WHEATLEY, M. D. The hypothalamus and affective behavior in cats. A study of the effects of experimental lesions with anatomic correlations. *Arch. Neurol. Psychiat.*, 1944, **52**, 296–316.
48. WHITE, R. K. The case for the Tolman-Lewin interpretation of learning. PSYCHOL. REV., 1943, **50**, 157–186.
49. WILLIAMS, K. A. The reward value of a conditioned stimulus. *Univ. Calif. Pub. Psychol.*, 1929, **4**, 31–55.

CONSCIOUSNESS AS ORGANISMIC PHYSIOLOGICAL FUNCTIONING

BY WILLIAM W. MARTIN

I. The Problem

Any attempt to interpret the concept of consciousness in terms of organismic functioning generated by patterns of metabolism may seem nothing other than the quintessence of intellectual temerity and even rashness to those psychologists who fashion their thinking mostly in conservative molds. Nevertheless, substantial beginnings toward this interpretation have already been made by workers in various fields of biological science, among whom are Jennings, Ritter, Child, Lashley, Herrick, Goldstein, Gesell, Needham; and in the domain of philosophy by Mead, Northrop, and Reiser, if only a few pioneers in this respect are mentioned. The hypothesis here presented is that consciousness is organismic behavior developing out of the primary metabolish of the organism. This interpretation, even though incompletely set forth, may serve to bring into more distinct relief some of the basic implications of the behavioral significance of the concept of consciousness as the most complex functioning of the personality, which is physico-chemical in its origin and development.

Perhaps most psychologists will assent to the observation, if it masks no theoretical squint or conceals no pet systematization, that psychology differs in at least one significant respect from other divisions of biological science in that its unique field is the study of organismic behavior at all levels of complexity as the basis of meanings in the adjustive service of the organism. Organismic behavior attains its highest level of complexity, that of differential awareness of organized meanings, in human behavior. Psychology must therefore come to grips especially with the problem of meanings, (1) what they are and how they develop, and (2) what contribution consciousness as individuated awareness of organized meanings makes to organismic behavior. According to this interpretation of the concept of consciousness, instead of asserting that consciousness has no place within the purview of psychology as an experimental biological science, or of maintaining that consciousness is an entity detached from nature and therefore *sui generis*, psychologists must face the problem of determining the nature and evaluating the function of consciousness as individuated awareness of organized meanings. The problem becomes even more formidable in that it involves issues of an epistemological nature. More than a few psychologists insist that under no circumstances must psychology be permitted to be tainted by having relations with problems centering in the nature of knowledge. At the present period this insistence has made psychology, as some psychologists interpret it, almost purely empirical in its methodology. But there are indications that the influence of this insistence is beginning to wane.

The organismic interpretation here presented is offered in the conviction that a theory of organism constitutes the most effective foundation as a basis for developing an interpretation of consciousness that will overcome what to some scientists seems the insurmountable difficulty of accounting for consciousness as a unity of organismic physico-chemical processes that cannot be wholly identified in terms of its sub-

sumed physiological components. The principle that underlies the resolution of this seeming insurmountable difficulty inheres in the philosophy of organism; it may be stated as the hierarchy of integrative levels of organization manifested in organisms. A corollary of this principle signifies that the complexity of organization, and therefore of functioning, attained at a given integrative level of organization does not exist at a lower level of integration. As Novikoff says: "What were wholes on one level become parts on a higher one. Each level of organization possesses unique properties of structure and behavior which, though dependent on the properties of the constituent elements, appear only when these elements are combined in the new system" (**55**, p. 209). Since consciousness is the meridian of levels of metabolic processes attained by the personality, it manifests functional characteristics that do not exist in any of the lower integrative levels of metabolic processes that are its components. The seeming paradox is thus resolved that, although consciousness is basically physiological in its nature, it exhibits behavioral complexities not to be found in its constituent physico-chemical processes. This concept of levels of organization also avoids the bewildering maze of contradictions and ambiguities involved in the futile attempt to take consciousness entirely out of the domain of physico-chemical processes, by making it a process of supposedly different nature, that is to say, one that is allegedly purely 'psychical.' By the interpretation here submitted, consciousness is a basic activity of the total personality that cannot be ignored; it poses a problem that must be squarely met and unequivocally solved on the basis of principles that satisfy the investigative, logical, and theoretical requirements of psychology.

II. THE NATURE AND DEVELOPMENT OF CONSCIOUSNESS

In a specific sense the meaning of an object, or an occurrence, or a total situation of any sort, is what an organism does when in interbehavioral contact with such object, occurrence, or total situation, and also the total internal effect of this activity, including especially the effect of the tissue-changes thus engendered in the behaving organism. From this perspective, the organism in its interaction with the environment, rather than the environmental or stimulating situation, primarily determines the nature of behavioral meanings; or, this point of view, in the words of Thurstone, 'dethrones the stimulus' (**72**, p. 364). The stimulus, or the environmental situation, contributes complementally to the origin of meanings in the sense of constituting the nexus, or setting, or mold in which the experiencing individual organizes its meanings. A six-year-old's characteristic definition of a knife as "something that you cut with," is a concrete illustration of the nature of a simple, definite meaning empirically derived. If the six-year-old is asked, soon after he may have painfully cut his finger, what a knife is, he is likely to answer in substance, "it is something that cuts your finger and hurts." The meaning of 'knife' has undergone a partial change, since this object has now become the referent for a somewhat different semantic complex of experiences. So it is with all our meanings, including those that are most highly abstract and generalized: *meanings epitomize or symbolize our experience, as influenced by the interrelation of our needs and our environmental contacts.*

Meanings are thus never static, but constitute a continual process of dynamic flux in behavior as the organism experiences new or more complex needs

in confronting a changing environment, which also is never static. Meanings are therefore a measure or a criterion of the adjustive consequences of behavior, as reflected in the internal condition of the organism. Mead expresses essentially the same thought, but from the angle of a somewhat different perspective, in saying, "Life becomes conscious at those points at which the organism's own responses enter as a part of the objective field to which it reacts" (48, p. 73). The criterion of being conscious implied in Mead's statement is the ability of an organism to make its own responses a part of the total objective situation toward which it reacts; in other words, whenever organisms respond objectively to their own responses they are conscious. In Mead's thinking at this point, to be conscious evidently signifies to be aware of meanings.

At once the question arises, what is the basis or framework of the dynamic process of continual flux in organismic behavior which is symbolized in meanings? As Jennings says of bacteria, "behavior under stimulation depends on the nature of life-processes—especially the metabolic processes." Continuing, he says further, "behavior that results in interference with the normal metabolic processes is changed, the movement being reversed, while behavior that does not result in interference or that favors normal metabolic processes is continued" (36, p. 39). All the facts so far brought to light concerning the behavior of higher animals and of man, such as the influence of a condition of objectively manifested emotionality in either rats or human beings on their respective modes of behavior, strongly tend to confirm Jennings's interpretation of the basic determination of behavior in bacteria as true also for all animals, including man. The inference appears sound, then, that the basis of meanings for all organisms is their normal metabolic processes. According to the interpretation here outlined, those metabolic processes, by means of which the on-going life of the organism is continued at the maximum level of well-being that the naturally reciprocative environment of the organism permits, are normal metabolic processes. These normal metabolic processes, therefore, *constitute the physiological function that is the framework or basis of the dynamic flux in behavior which meanings symbolize,* and also provide the range of modality within which the organism differentiates or discriminates its meanings.

The meaningfulness or significance or primary symbolism of behavior, as registered internally in all the tissues of the behaving organism, therefore, is the relation of this behavior to the normal processes of metabolism, either current or tending to occur. The normal processes of metabolism are thus the semantic frames of reference for all behavior. Since the normal processes of metabolism for any organism are relatively constant under normally stable environmental conditions, the meaningfulness of its behavior also tends to be relatively constant for that organism. The consistency of behavior is thus assured. Every organism, under what for it are normal environmental conditions, tends to become organized, and its behavior tends to become canalized in the direction of continuing its normal metabolic processes; or, in other words, *the basic dynamism of every organism is the continuance of its normal primary metabolism.* The goals of an organism, the degree to which it becomes energized in the pursuit of its goals, and its effectiveness in attaining them are all functions of its metabolism. The principle seems valid, then, that in the primary metabolic processes of human organisms inhere the potentialities for the development of all their marvelously

complex and highly coordinated modes of activity, which culminate in thinking-behavior. Whether or not these potentialities become actualized in achievement is a function of the interaction of the personality and its environment, in which the appropriate conditions are supplied by the environment. The aspect of behavior which registers internally in all the tissues of the behaving organism this behavioral dynamism may be denominated experience; the aspect of behavior which is the individuated awareness of this registering experience may be called consciousness. According to this view, "consciousness presupposes experience and not experience consciousness," in the words of Whitehead (76, p. 83).

This distinction between experience and consciousness does not imply a qualitative difference between these two functional aspects, but only a difference in degree of development; it indicates that experience is a functional aspect of behavior which precedes that of consciousness, in both ontogenetic and phylogenetic development. Organisms experience the internal changes in their own tissues, which result from their own behavior, before they have attained a level of development that enables them to be consciously aware of the differential significance of these internal changes. According to this interpretation, experience is both a prerequisite for and a component of consciousness. Jennings's careful and extended study of what he recognizes as social behavior in unicellular organisms confirms this conclusion. He cites the mating behavior of pairs of *Paramecium bursaria*, a species of typical ciliate infusoria, that illustrates behavioral experience, as internal registering of tissue-changes resulting from behavior, without conscious awareness of the behavioral meaning of such experience.

In discussing this mating behavior, Jennings says: "The infusorian has no awareness of the complex social system (meanings) into which its behavior fits, for the good reason that there is no way in which it could acquire the data requisite for being aware of it—even if it has or had the capacity of conscious awareness" (36, p. 545). Jennings previously states that this type of behavior of *Paramecium bursaria* "is of widespread occurrence among certain classes of Protozoa" (37, p. 544). In fact, he makes an even more sweeping statement concerning the extent of mate-seeking behavior, in saying, "It (mate-seeking behavior) is found generally in unicellular organisms. Indeed it is doubtful whether any organisms exist in which it does not occur" (37, p. 546). On the basis of the evidence that Jennings has assembled and established as convincing, the conclusion seems factually sound that, in functional development, both individual and racial, the aspect of behavior here designated as experience precedes the aspect of behavior here designated as consciousness.

This process of internal organismic registering of the behavioral modifications engendered in an organism by its own behavior, that is to say, this process of experience, is one phase of the succession of physiological states which constitute the life-span of an organism. Physiological states may be described as unitary patterns of the waxing and waning of dynamic bio-physical and bio-chemical processes or patterns of metabolism, ordered by their relation to the adjustive needs of the organism in the course of its interaction with its environment. Experience is thus derivative or emergent physico-chemical functioning issuing from these primary patterns of metabolism. It is therefore one level of integration in the hierarchy of levels of organization that constitutes the life-continuum or sequence of higher

organisms. In other words, ***human experience, as here interpreted, is a behavioral process that is a constituent of the entire world of natural processes; human experience is within nature.*** It is just as natural for one to write a sonnet as it is for one to breathe; the difference is in degree of complexity. If Jennings is correct in his doubt that any animal organisms exist in which behavior in seeking mates does not occur, and strong evidence can be arrayed to support his doubt, then experiencing as internal tissue-registering of behavioral outcomes occurs throughout the entire range of species of animal organisms. Since no definite dividing line can be established between plant and animal systems of protoplasms, and since all protoplasms possess in some degree the characteristic of excitability and its transmission by unspecialized tissue, it appears that the *basis* of experiencing is to be found in the behavior of all living organisms, whether classified as plant or animal. The mode of metabolism known as excitability of unspecialized tissue and its transmission by unspecialized tissue are therefore, to use Whitehead's words, "the identical elements connecting experience and physical science."

However, Whitehead peremptorily challenges the conclusion that the process of human experiencing is 'within nature' in saying, "But any doctrine, which refuses to place human experience outside nature, must find in descriptions of human experience factors which also enter into the description of less specialized natural occurrences. If there be no such factors, then the doctrine of human experience within nature is mere bluff, founded upon vague phrases whose sole merit is a comforting familiarity. We should either admit dualism, at least as a provisional doctrine, or we should point out the identical elements connecting human experience with physical science" (75, p. 237). Whitehead very properly issues this challenge in order to place the responsibility of identifying the identical elements connecting human experience with physical science, precisely where it belongs—upon the principle that human experience is within nature.

Not only does the established fact of excitability of unspecialized tissue and the transmission of this excitability by unspecialized tissue, as a universal characteristic of protoplasms, answer Whitehead's challenge, by constituting the identical elements connecting human experience with physical science, which is the condition that his challenge demands, but it distinctly appears that Whitehead himself meets his own challenge in saying: "But the living organ of experience is the living body as a whole. Every instability of any part of it—be it chemical, physical, or molar imposes an activity of readjustment throughout the whole organism. In the course of such activities human experience has its origin. The plausible explanation of such experience is that it is one of the natural activities involved in the functioning of such a high-grade organism" (75, p. 289). According to Whitehead's own answer to his challenge, then, the physico-chemical activities, by which the human organism stabilizes its chemical, physical, or molar instabilities, constitute the identical elements connecting human experience with physical science, since, as he implies, these activities at the same time constitute the origin of human experience and also provide some of the basic elements with which physical science deals. In thus answering his own challenge, Whitehead also confirms another inference included in the position here advocated, to the effect that experience is an organismically total function; that is to say, it involves all the tissues of the experiencing organism.

Furthermore, if Jennings is correct also in his supposition that the seeking of mates appears to be the behavior that is the fountain-head of both social behavior and self-consciousness (37, p. 546), then consciousness is definitely referable to a mode of behavior, which in *Paramecium bursaria* is mate-seeking. Consciousness is thus organismic functioning which emerges from the cumulative complexity of successions of physiological states, and as such may be further described as that *organismic physiological activity of living organisms which is the individuated or discriminative awareness, in the mode of differential response, of patterns of behavioral meanings.* The foregoing statement that consciousness 'emerges' from successions of patterns of physiological states implies none of the mysticism or metaphysical haze, which by some thinkers has been made to invest the term *emerge.* It is used in precisely the same sense that the term is used in the statement that a chemical compound *emerges* from the action of its elements when the conditions for their chemical union are favorable; or, in the same sense that it may be said that heat *emerges* when two solids are rubbed against each other.

Like every other complex organismic physiological functioning, consciousness, at the highest inorganic level of development, is not yet individuated as a specific process; but like all other such complex processes, from the outset of the organic level of development, if the general principle of evolutionary development is factually justified, consciousness becomes individuated in the long course of progressive evolutionary changes as organismic development continues toward greater complexity. Among biological scientists the conviction is steadily growing that organic development is continuous with inorganic development. Thus it is that consciousness has 'come out of nature,' to use the expression of Northrop when he speaks of the genesis of living organisms (54, p. 217). Consciousness may therefore be the nexus of nature's most complex energy-changes, which are one extreme of a continuum, and such primordial modes of cosmic energy as thermo-dynamic, electrodynamic, and optic, are the other extreme; in fact, biological science is already definitely on the way toward demonstrating the truth of this hypothesis, if it has not already done so.

As concrete evidence that this demonstration is well on the way, the work of Stanley and other biologists on viruses may be cited. Stanley says:

"It is difficult, if not impossible, to place a sharp line separating living from nonliving things when one considers a series of structures of gradually increasing complexity such as would be represented by hydrogen, water, benzene, ergosterol, egg albumen, insulin, pepsin, tobacco-mosaic virus, papilloma virus, vaccine virus, pleuro-pneumonia organism, bacteria, a mammal like a dog, and intervening entities. The problem is similar to that encountered when an attempt is made to determine the exact point at which one color blends into another in a color spectrum or when one attempts to establish just where acid becomes alkaline. . . . I believe that the work on viruses has provided us with new reasons for considering that life as we know it owes its existence to a specific state of matter and that the principle of the vital phenomenon does not come into existence suddenly but is inherent in all matter" (67, p. 150).

Needham implies the same principle of continuity of the organic and inorganic: "We cannot but consider the universe a series of levels of organization and complexity, ranging from the sub-atomic level, through the atom, the molecule, the colloid particle, the living nucleus and the cell, to the organ and the organism, the psychological and the sociological entity" (52, p. XIV, XV).

There appear to be strong factual grounds for the hypothesis that consciousness has its functional origin in the basic patterns of metabolism of the organism. When in the course of 'evolutionary naturalism,' to use Needham's phrase, these basic patterns of metabolism have become the integrative level of complexity here called experience, and when later in this evolutionary process the higher level of complexity here designated as consciousness has appeared, the two functional levels constitute a unity which is the nexus of all behavioral organization and relationships of the personality. Meanings symbolize the experience of the personality, and consciousness functions as the individuated awareness of the patterns of meanings as they become organized by the personality in the course of interacting with its environment in meeting its needs. The specific nature of the bio-physical and biochemical processes involved in this cumulative development of complexity of metabolic processes must be a further problem in many closely interrelated areas of the physical, chemical, and biological sciences. Until these areas have made further progress in discovering the precise nature of these physico-chemical processes, psychology cannot be more definite in its hypothesis concerning them.

III. THE BEHAVIORAL CONTRIBUTION OF CONSCIOUSNESS TO ORGANISMIC LIFE

Consciousness as the differentiating-integrating, or organizing, activity of the organism enables it to align itself with the rest of nature. The higher the level of integration attained by consciousness, the more completely is the organism enabled thus to align itself. By means of its differentiating or analytical aspect, consciousness is the highest degree of the selective function, which enables the organism to concentrate its resources and to discern the relevant environmental factors in centering upon its most significant problems or needs in any given situation; by means of its integrating or synthesizing aspect, consciousness is the highest degree of the correlative mobilizing function of the organism, which enables it to marshal its resources and to relate the relevant elements of its environment in meeting these needs. In this way man is able to relate himself to the other systems of energies in the world far more completely and effectively than can any other species of organisms. Evidence of this superiority of man is easily supplied by a comparison of the extent to which man uses the other systems of energies in the world with the extent to which other species use these same systems of energies. The inference seems justified, then, that consciousness links the organism with all the other systems of energies in the cosmic order. Consciousness is thus in no sense activity of a supernatural, mystical, or mysteriously 'intuitive' character that stamps the higher organisms as not identifiable with the rest of nature, including the lower organisms that have not, in all probability, attained the integrative level of organization represented by consciousness. In other words, consciousness by its own nature is itself prima facie evidence that organisms at this integrative level of organization, along with all other living organisms, are an integral part of the macrocosm.

Figuratively speaking, consciousness is of the earth earthy; but at the same time it is the loftiest manifestation of the human personality, since it is the basis of intelligent behavior and consequently the fountain-head of all social behavior, including ethical behavior and the promptings of so-called moral conscience. By this fact of being an

attribute of the physical components of the personality, as well as at the same time being the source of the highest complexity of behavior attained by the personality, consciousness confutes the attitude of those theologies that regard the physical or material elements of the personality as base, carnal, or ignoble, in opposition to the so-called spiritual elements of the personality. The origin, development, and functioning of consciousness is such that consciousness on its own account does not warrant any 'bifurcation of nature,' to use Whitehead's phrase; nor does the meaning of consciousness warrant any 'bifurcation' of the organism. On the contrary, human consciousness is pre-eminently the epitomizing, organizing, unifying function of the personality. Only in the case of disordered, disrupted or disintegrated personalities may consciousness under conditions of unusual frustration function as a bifurcating component. If the unifying, harmonizing function of consciousness in organizing all elements of the human individual into a personality of great potential abilities were generally recognized, uninfluenced by the bias of theology, national distrust, race prejudice, or that of any other source, the inherent dignity and worth of the personality would be a much stronger and more humanizing cultural influence than it is at present.

Among these theologies, a certain kind of present-day theology, prevalent throughout the major portion of the Western world, medieval in its origin and in its perspective, and mistakenly called Christian, minimizes instead of justly exalts the inherent grandeur and nobility of consciousness as the most complex behavioral level of the personality and thereby distorts, lessens, and degrades the humanizing influence of consciousness as a dynamic element of culture. Surely no one would go so far as to maintain that this minimizing influence of so-called Christian theology is mainly responsible for the excesses of crass materialism, the debauchery of stark sensualism, the downright lust for dictatorial power, the mad desire for private profit, that now dominate our Western culture; but more than a few thoughtful students of Western ideologies will doubtless agree that this minimization on the part of prevailing theology has contributed measurably to the threatened decadence of our Western culture. Undoubtedly our practical workaday life sorely needs to be pervaded by a far more exalted notion of the potential worth of the individual and the surpassing power of organization of his consciousness. Rather than a renaissance of 'rugged individualism,' with all the damnable power of ruthless exploitation of the weaker many that the 'rugged' few inevitably acquire during the régime of this principle, humanity needs a flowering of ameliorative individualism, dedicated to the principle of mutuality of participation by all individuals in the finest realizations of life of which each one can become capable. A sound psychology of the personality and its consciousness could and should assume a responsibility for nurturing in men and women the enlightened motivation that would issue from a true understanding of the part that human consciousness plays in the bettering and in the worsening of human affairs.

Should the objection be raised that as a science psychology is descriptive rather than normative and therefore has no responsibility for the morals of the individual, the rejoinder would be that no true science of psychology atomizes the personality that it studies by abstracting, for instance, the ethical aspect of the personality and, disclaiming all responsibility for understanding the ethical behavior of the personality, then assumes that what is left of the

personality after this abstraction is the total integrated personality, and proceeds by the study of such atomized remnants to the derivation and formulation of the principles underlying the behavior of total integrated personalities in the mutuality of their interactions. During recent years the attitude has been growing in the individual consciousness of many scientists that if psychology is to attain its full development it must be studied and investigated not only in the calm, detached, impersonal setting of the ivy-towered laboratory but also in the midst of the sweating, swearing, throbbing life of the farm, the factory, the counting-house, and the marts of trade. This attitude has been much quickened by the recent successful fissioning of the atom and the perversion of the mighty energy of billions of atoms thus liberated to the horrible uses of war. The conviction that psychology should become more humanizing has been cogently expressed by the veteran psychologist, Yerkes, in these words: "Psychology, I have maintained, should be concerned as a profession primarily with the improvement of human nature and the enhancement of individual and social human values" (82, p. 542).

In more specific terms, the unique function of consciousness is to enable the organism, by means of its augmented acquisition of more complex behavioral meanings to become aware of the meanings of increasingly complex needs, and also on the same basis to utilize to a greater extent and in increasingly complex ways the energies of the world, including its own, in meeting these needs. Among all species of organisms there is a high positive correlation between the range and complexity of needs that an organism gives objective evidence in its overt behavior of experiencing and the level of integrative-differentiative behavior that the consciousness of the organism has developed. In other words, the level of integrative-differentiative behavior that the consciousness of an organism has attained is proportional to the range and complexity of needs, which that organism shows objective evidence in its behavior of being able to experience. For instance, an infusorian, a representative of unicellular organisms, is found on careful and extended observation, under its normal conditions of life, to be capable only of behavior that, relative to the behavior of highly developed organisms, is no more than slightly organized, that is to say, integrative-differentiative in functional efficiency; and the range and complexity of needs that the infusiorian gives objective behavioral evidence of experiencing is correspondingly limited. On the other hand, the level of organized behavior of such high-grade organisms as primates is relatively high, and the range and complexity of needs that they give objective behavioral evidence of experiencing is correspondingly high. As here employed, the term *need* is tainted with no subjectivism or other form of anthropomorphism. It implies only those elements and conditions without which an organism cannot maintain its normal processes of metabolism and therefore will eventually perish; and the phrase 'normal processes of metabolism' has already been described in a manner that frees it also from the ugly imputation of subjectivism! It should be evident that proteins, fats, carbohydrates, oxygen, water, certain mineral elements, to mention only a few needs, are all requirements of animal organisms, since without them these organisms can not live. Surely, then, these elements may be classed as *needs* without justly incurring the charge of subjectivism.

The principle that the range and complexity of an organism's needs are

correlative with the hierarchy of integrative levels of patterns of behavior attained by that organism is not invalidated, even though the use of such terms as 'tropisms,' 'reflexes,' and 'instincts' may be employed to describe the behavior of organisms or to characterize their needs, which such behavior indicates objectively. An organism's so-called tropisms, reflexes, or instincts can be no more or no less complex, or no more or no less extensive in range, than is the range and complexity of its inferred ability, as implied by its manifest behavior, to experience needs, for the reason that these descriptive concepts are only categories of classification and have no necessary significance for the correlative principle that relates the organism's ability to experience needs and its capacity to organize its behavior in meeting its needs. Organisms behave as they do in a given situation, not because they are equipped with so-called tropisms, reflexes, or instincts, but for the reason that in so doing they are fulfilling certain organismic requisites, or needs, which are made objectively evident by their behavior. They can act in ways that enable them to meet effectively their needs, for the reason that for every need that an organism shows objective evidence of experiencing it has developed suitable ways of meeting this need, provided that the environment affords appropriate opportunities.

In the case of lower organisms, then, it seems factually sound to conclude that a lower organism's capacity to experience is the equilibrating function by which it maintains a balance between the capacity for behavior suitable for fulfilling its needs and the range and complexity of these needs; in the case of higher organisms, it appears that the organism's consciousness is a similar equilibrating function. Experience, as the term is here used, is therefore an indispensable level of organization in the life-processes of lower organisms; and both experience and consciousness, as these terms are here used, are necessary or indispensable levels of organization in the on-going life of higher organisms, if this life maintains its ongoing proclivities. Strictly speaking, both terms, experience and consciousness, always imply a content—something that an organism experiences and something which an organism differentiates in experience. But for purposes of systematic investigation, that should result in both more precise analysis and more comprehensive synthesis, the functional nature of experience and of consciousness may be abstracted from the content toward which they function. However, this abstraction is always a process of reflective thinking and never a direct process of concrete experience.

The dimensions of life which any organism attains are a function of that organism's capacity to learn to envisage in imaginal anticipation the meanings of life, together with its ability to use its own energy and also other systems of energy, both organic and inorganic, to achieve its own self-realization in terms of these meanings. In this respect the difference between man as the most highly developed species of organisms and the amoeba as representative of the lower organisms is definite and very considerable, although in fundamental modes of energy and of organization the two species are closely similar. This marked difference between man and amoeba is indicated most clearly perhaps by the contrast between the consciousness of man and what in all probability is the ability of the amoeba to experience in a vague, primordial sort of way the fact of its merely vegetative kind of existence.

It should be kept in mind, however, that the amoeba, by its long record, evidently must be able to get along on the

amoeboid level of existence quite as well as man does on the human level. In other words, we have no reason, on a relative basis, for 'high-hatting' our distant cousin, the amoeba. In fact, there are substantial grounds for the inference that in some respects the amoeba is actually relatively superior to man, who has so haughtily dubbed himself *homo sapiens!* If this observation be challenged as a base slander against man, let the challenger consider the implications of this fact: The amoeba has solved its life problems on its own amoeboid level of life for a period approximating hundreds of millions of years—possibly as many as a billion years—and is going strong today; in contrast, man attained the lowest human level of development probably as recently as sometime between half a million and a million years ago, but even now after this comparatively short period is having a desperately hard time in maintaining his high status as genus homo, even if nothing be attempted toward making further progress. From this perspective, perhaps man should be ashamed of himself.

The final test of self-realization, or the end-result, toward the consummation of which every living organism uses its energy and mobilizes its behavior is its ability to use its own energy and also that of other systems of energy, both organic and inorganic, in meeting the requirements that are the indispensable conditions of its continued existence, that is to say, its needs. In higher organisms the hierarchy of levels of organization characterizing consciousness constitutes the instrumental means by which this realization is accomplished. The highly developed human consciousness as compared with its remote prototype, protoplasmic excitability and its transmission by amoeboid tissue, accounts for man's marvelous achievements in capturing the energies of nature and converting them to his own use. In this success the significance of the complexity of human behavioral organization is the paramount component. The lower organisms possess in a rudimentary sense all the modes of energy that man possesses, but the tremendous difference between the behavior of lower organisms and that of man is measured primarily in terms of units of complexity of behavioral and correlatively structural organization. For instance, there is sound factual justification for Coghill's estimate that an increase of approximately one hundredth of a millimeter in the growth of the axon and the dendrite terminals of the salamander enables it to change from the condition of a relatively inert organism to the status of an active, seeking animal (15, p. 84–85).

The same principle of difference in complexity of behavioral and structural organization accounts also for man's superiority over the lower organisms in the ability of organisms to utilize other systems of energy in meeting their needs. Lower organisms can and do use both organic and inorganic systems of energy in realizing themselves as ongoing organisms, but this utilization is on the plane of automatic behavior that has not reached the stage of rationality. In man this utilization has reached the plane of rationality, and the consciousness of human beings is the functional measure of this rationality. Today the thinking men and women of all nationalities contemplate in almost awe and bewilderment the possibilities for human betterment or for human destruction that inhere in the successful fissioning of the atom on a large scale. But unthinking men and women, who unfortunately so largely outnumber those who reason or at least try to reason intelligently, persist in demanding that the affairs of the world shall continue

to be managed precisely as they were before the splitting of atoms on a large scale was an accomplished fact.

Perhaps one explanation of this stolid persistence which threatens to destroy civilization is to be found in the inertia of race-old attitudes, habits, modes of thinking, and the influence of the almost static social institutions which have developed out of these crustacean-like rigidities. The amoeboid sluggishness of man in failing to enrich his life by utilizing to the fullest extent the energies of nature which the brilliance of his consciousness has enabled him to capture, is to our lasting disgrace as human beings. Evidently human consciousness is lacking in plasticity and in symmetry of organization rather than in rational acumen. Nowhere else on our planet have the conditions for the full utilization of the captured energy of nature in enriching the human personality been on the whole as favorable as they have been and are right here in our own nation, but we have done no better relatively than have other nations less favorably situated. Yet we brag and strut and throw out our chests in proclaiming that we are the most competent nation on earth in bearing the torch of civilization!

At the level of human development the functional complexity of consciousness has become so great that man in his collective capacity, through the impact supplied by his intra- and inter-group contacts, has developed a depth, range, and complexity of meanings that in their correlative integration and individuation of organization have become language, tools, a number system, machines, an economic system, art, science, government, religion—in short, culture, that comprises all the agencies and institutions of a highly intricate and subtly interrelated social order. Breasted has expressed substantially the same thought in saying, "It required probably not less than a million years of human development for man to build an enlightened life out of which began to issue the Age of Character" (7, p. XXIV). Breasted is here referring especially to the development of a recognition by man of the ethical import and values, that is, of conscience, in human consciousness; but he is implying a general background of behavioral development, of which consciousness is the foundational process. Consciousness is therefore the cultural framework of conscience, as the race builds an enlightened life. Culture is pre-eminently the achievement that distinguishes the human species as unique among the living organisms of our planet; human consciousness is the originator of culture and the arbiter of its continued development. Culture therefore emanates neither from the 'glory that was Greece' nor from the 'grandeur that was Rome.' No other species has achieved a development enabling it to organize its experience and structure its consciousness in a content that even remotely approaches human culture.

As human personalities we have reason to feel both pride and humility in contemplating the structured content of our racial consciousness as it exists in the social agencies and institutions that constitute human culture. Progress that the human race has made, which is indicated by achievements in all forms of art, in literature, science, medicine, inventions, almost defies description; progress in morals, in religion, government, family life, and in many other modes of social relationships has been much less magnificent: We still wage global war, as well as carry on barbarous and destructive strife in the form of rackets, profiteering, black-markets, monopolies, cartels, lock-outs, strikes, and many other forms of violent plundering that are protected either with the tacit consent of public opin-

ion or in open violation of it. When we face the responsibility, as we must if we are to continue to be the human species, of not only living up to this heritage of culture but also of enriching and ennobling it, our course of action is characterized by confusion, uncertainty, indecision, and a tragic selfishness that at times is almost brutish in its lack of social motivation.

Since culture is the organized meanings that symbolize human experience as these meanings become the structured content of human consciousness, culture can never be static, but is always a constant flux of behavior as consciousness develops. Nor can culture ever be a discrete, autonomous entity, external to and independent of the characteristics of human consciousness, for the reason that culture is always the organized meanings of human individual and social consciousness. Culture is thus here viewed as intrinsic or immanent in human consciousness, rather than as extraneous to consciousness; as inherent and experientially acquired, rather than as external and conventionally acquired. Culture may well be regarded as an objective record of the temporal succession of behavioral patterns of experience symbolized in meanings that become structured in social agencies and institutions, rather than as a static entity possessing independent values that transcend the influence of the origin of culture in human consciousness.

The meaning of culture is far greater than merely academic; nor is it restricted to the philosophic import of culture. The psychology of culture cannot be more than briefly suggested within the limits of this discussion. It should be said, however, that the meaning of culture has a significance in human affairs that includes practical-life problems with a setting in the sciences, in aesthetics, in morals, in religion, in education—in short, in all the areas of human living. As an illustration, both the science and the practical methodology of our system of public education are deeply influenced by the concept of culture as a static entity external to human consciousness. Such expressions as 'cultural subjects' as separate from and largely opposed to so-called vocational subjects in the school curriculum indicate this influence. Similarly, the categories of 'liberal arts colleges' and 'vocational colleges,' together with their functional distinctions, imply the same influence of the concept of culture as an external entity. Such compound terms, as 'religious-secular,' 'theory-practice,' 'mind-body,' 'spirit-flesh,' also imply a strongly prevalent notion that culture is a dualism in which there are sharp opposites of meanings and consequently that cultural values involve a corresponding dichotomy.

But the psychology of culture indicates one kind of variation inherent in elements of culture that is frequently not recognized. Since consciousness involves the entire gamut of experience, culture is bound to symbolize the same total range of experience. Elements of experience differ as to their relative value in contributing to human worth and progress, as measured by prevailing standards existing at any given period in any given social group. Similarly, different elements of culture differ in their relative value in symbolizing experiential elements of worth and progress, as measured by these same standards. Failure to recognize this principle of the differential value of different elements of culture in symbolizing elements of experience of differential worth has resulted in a more or less false scale of values that prevails not only in our philosophy of life but also in our practical, every-day living.

Strictly speaking, in any national group any element of experience that

becomes symbolized in meanings which acquire permanence as social agencies or institutions has some degree of cultural value. What degree of cultural value the element has depends upon its relation to the prevailing standards by which cultural values are measured. For instance, during pioneer days in rural America, when in some sections domesticated hogs were permitted to range over a large wooded area to secure food, a hog-calling voice that could be heard by these animals over long distances was undoubtedly rated as possessing considerable cultural value, and correctly so, psychologically speaking. Today, in one of the richly furnished music salons of an elegant home in any of the most exclusive residential districts of our metropolitan areas, a hog-calling voice, unless it had previously been metamorphosed into a grand-opera voice, would be heard by the assembled disciples of Orpheus with a consternation closely bordering on horror at such a 'boorish' demonstration of 'culture,' and again correctly so, psychologically speaking. Cultural value is always determined by the relation of the meaning of the content of culture to prevailing social standards of cultural value. It should thus be evident, according to the view here presented, that no absolute value can inhere in the content of culture.

IV. CONCLUSIONS

1. The *basis* of consciousness is the primary metabolism of individual systems of protoplasms, ***which is a universal function of living organisms.*** Consciousness is, therefore, neither a mysterious phenomenon, which is *sui generis* in its origin, nor a by-product of the biological order, which is adventitious in its origin.

2. Consciousness is an organismic nexus or complex or syncytium of physico-chemical processes, rather than a discrete entity or a static condition; and it individuates relatively late in the course of the evolutionary development of the higher organisms. Human consciousness is thus the climax of cosmic development, as far as we know this development.

3. Human consciousness is the personality functioning at its most complex level of physiological integration; and the biological principles which govern its functioning do not appear at less complex levels of functional integration.

4. Human consciousness is the supreme organizing, or integrating-differentiating, function of the personality, which develops out of the primary metabolic processes of the human organism.

5. Although it is basically a physico-chemical process, the organizing function of consciousness is governed by principles that are not operative at the less complex level of its physiological components, for the reason that the organizing function has not yet become individuated at this less complex level.

6. Instead of differentiating man from the rest of nature as constitutionally different, consciousness characterizes man as integrated or harmonized not only with the lower organisms but also with the inorganic systems of the cosmos. Consciousness is therefore within nature; it is the equilibrating function which enables the personality to maintain a balance between its needs and its ability to use its own energy and that of its environment in meeting these needs.

7. As the basis of all intelligent behavior, human consciousness unifies the behavior of the personality in terms of rationality. The supreme function of consciousness, therefore, is to be the arbiter of the source of both man's potentialities and also his limitations, that is to say, the arbiter of his action-system.

8. The organized meanings that symbolize the conscious experience of successive generations, as they come and go, become structured in social agencies and institutions, to constitute human culture, the priceless heritage of the race and the immortality of the individual. Cultural values are thus determined by the relation of the content of culture to the prevailing standards of value that have developed in the social consciousness of the group; no absolute value can therefore inhere in the content of culture.

9. Human consciousness belongs to the order of nature; its development is accounted for by the same basic principle that accounts for all other complexities of nature—that of cumulative evolutionary increase in complexity; it is the zenith of the hierarchical continuity of the integrative levels of organization that unifies the entire cosmic order, as we know this order; it continually flowers in culture that modifies and is modified by successive generations, and thereby becomes a time-binding means that makes human development a cumulative process, in enabling each generation to begin where its parent generation leaves off; and it functions as a succession of organismic patterns of physico-chemical processes which generate a wealth and variety, a richness and depth, and a beauty of meanings in the life of man that immeasurably transcend the dimensions of life attained by any other species.

BIBLIOGRAPHY

1. ALEXANDER, J. *Colloid chemistry.* (4th Ed.) New York: Van Nostrand, 1937.
2. BAKEWELL, C. M. *Source book in ancient philosophy.* New York: Scribners, 1909.
3. BEUTNER, R. *Life's beginning on the earth.* London: Chapman & Hall, 1939.
4. BENTLEY, M. Mind, body, and soul in medical psychology. *Am. J. Psychol.*, 1933, **45**, 577–591.
5. BIANCHI, L. *The mechanism of the brain and the function of the frontal lobes.* Edinburgh: Livingstone, 1922.
6. BINET, A. *The psychic life of micro-organisms.* Chicago: Open Court, 1889.
7. BREASTED, J. H. *The dawn of conscience.* New York: Scribners, 1933.
8. BROAD, C. D. *Mind and its place in nature.* New York: Harcourt-Brace, 1925.
9. BURR, H. S. An electrodynamic theory of development. *J. comp. Neurol.*, 1933, **56**, 347– .
10. ——, & NORTHROP, F. S. C. The electrodynamic theory of life. *Quart. Rev. Biol.*, 1935, **10**, 322–333.
11. CARMICHAEL, L. The experimental embryology of mind. *Psychol. Bull.*, 1941, **38**, 1–28.
12. CHILD, C. M. *Origin and development of the nervous system.* Chicago: Univ. Chicago Press, 1921.
13. ——. *Physiological foundations of behavior.* New York: Holt, 1924.
14. COBB, S. *Foundations of neuropsychiatry.* Baltimore: Williams & Wilkins, 1941.
15. COGHILL, C. E. *Anatomy and the problem of behavior.* New York: Macmillan, 1929.
16. CORNER, G. W. *Ourselves unborn: natural history of the human embryo.* New Haven: Yale Univ. Press, 1944.
17. DEWEY, J. The reflex-arc concept. *Psychol. Rev.*, 1896, **3**, 357–370.
18. ——. *Experience and nature.* Chicago: Univ. Chicago Press, 1925.
19. EVE, F. C. In the beginning. *The Atlantic Monthly*, 1923, **131**, 664–677.
20. GELHORN, E. *Autonomic regulations: their significance for physiology, psychology and neuropsychiatry.* New York: Interscience Publishers, 1942.
21. GESELL, A. *Genius, giftedness, and growth.* The March of Medicine. New York: Columbia Univ. Press, 1943.
22. ——. *The embryology of behavior.* New York: Harper, 1945.
23. GESELL, R., HANSEN, E. T., & WORZNIAK, J. Humoral intermediation of nerve-cell activation in the central nervous system. *Amer. J. Physiol.*, 1943, **138**, No. 5, 776–791.
24. GOLDSTEIN, K. *The organism.* New York: American Book Company, 1939.
25. GOLDSCHMIDT, R. *Material basis of evolution.* New Haven: Yale Univ. Press, 1940.
26. GORTNER, R. A. *Outlines of biochemistry.* New York: Wiley, 1938.
27. HARTMAN, R. J. *Colloid chemistry.* Boston: Houghton-Mifflin, 1939.
28. HENDERSON, L. J. *The fitness of the en-*

vironment. New York: Macmillan, 1917.
29. ——. *The order of nature.* Cambridge: Harvard Univ. Press, 1935.
30. HERRICK, C. J. *Neurological foundations of animal behavior.* New York: Holt, 1924.
31. ——. *The thinking machine.* Chicago: Univ. Chicago Press, 1929.
32. ——. *Introduction to neurology.* (5th Ed.) Philadelphia: Saunders, 1931.
33. HOLT, E. B. *The concept of consciousness.* New York: Macmillan, 1914.
34. JAMES, W. Does consciousness exist? *J. Philos.,* 1904, 1, 477–491.
35. ——. *Prägmatism.* New York: Longmans, 1907.
36. JENNINGS, H. S. *Behavior of the lower organisms.* New York: Columbia Univ. Press, 1915.
37. ——. The beginnings of social behavior in unicellular organisms. *Science,* 1940, 92, No. 2398, 539–546.
38. JOHNSTONE, J. *The mechanism of life.* London: Edwin Arnold, 1921.
39. KANTOR, J. R. Current trends in psychological theory. *Psychol. Bull.,* 1941, 38, 29–65.
40. KEPNER, W. A. Cartesianism is becoming less a dogma. *Science,* 1934, 80, No. 2062.
41. KOFFKA, K. Perception: an introduction to the Gestalt-Theorie. *Psychol. Bull.,* 1922, 19, 531–585.
42. KORZYBSKI, A. *Science and sanity.* New York: The Science Printing Company, 1941.
43. LASHLEY, K. S. The behavioristic interpretation of consciousness. *Psychol. Rev.,* 1923, 30, 237–272, 329–352.
44. ——. *Brain mechanism and intelligence.* Chicago: Univ. Chicago Press, 1929.
45. ——. Coalescence of neurology and psychology. Symposium on recent advances in psychology. *Proc. Amer. Philos. Soc.,* 1941, No. 4, 461–470.
46. MARTIN, W. W. Some basic implications of a concept of organism for psychology. PSYCHOL. REV., 1945, 52, 333–343.
47. MAXIMOW, A. *Textbook of histology.* Philadelphia: Saunders, 1942.
48. MCCLUNG, C. E. Evolution of the germplasm. *Science,* 1941, 93, No. 2412, 265–268.
49. MEAD, G. H. *The philosophy of the present.* Chicago: Open Court Publishing Company, 1932.
50. NEEDHAM, J. *Chemical embryology.* (3 vols.) Cambridge: University Press, 1931.
51. ——. *Order and life.* New Haven: Yale Univ. Press, 1936.
52. ——. *Biochemistry and morphogenesis.* Cambridge: University Press, 1942.
53. NORTHROP, F. S. C. The macroscopic atomic theory. *J. Philos.,* 1928, 25, 449–467.
54. ——. *Science and first principles.* New York: Macmillan, 1931.
55. NOVIKOFF, A. B. The concept of integrative levels and biology. *Science,* 1945, 101, No. 2618, 200–215.
56. OGDEN, C. K., & RICHARDS, G. A. *The meaning of meaning.* New York: Harcourt-Brace, 1923.
57. OSBORN, H. F. *The origin and evolution of life.* New York: Scribners, 1917.
58. PAGE, I. H. *Chemistry of the brain.* Baltimore: Thomas, 1937.
59. RASHEVSKY, N. *Mathematical biophysics.* Chicago: Univ. Chicago Press, 1938.
60. ——. *Advances and applications of mathematical biology.* Chicago: Univ. Chicago Press, 1940.
61. REISER, O. K. *Philosophy and the concepts of modern science.* New York: Macmillan, 1935.
62. ——. *The promise of scientific humanism.* New York: Piest, 1940.
63. RITTER, W. E. *The unity of the organism.* (2 vols.) Boston: Badger, 1919.
64. SHELDON, W. H., *et al. The varieties of human physique.* New York: Harper, 1940.
65. SHERRINGTON, C. *The brain and its mechanism.* London: Cambridge Univ. Press, 1933.
66. SINNOTT, E. W. The cell and the problem of organization. *Science,* 1939, 89, No. 2299, 41–46.
67. STANLEY, W. M. Some chemical, medical, and philosophical aspects of viruses. *Science,* 1941, 93, No. 2407, 145–151.
68. ——, & ANDERSON, T. F. A study of purified viruses with the electron microscope. *J. biol. Chem.,* 1941, 139, 325–338.
69. STEVENS, S. S. Psychology and the science of sciences. *Psychol. Bull.,* 1939, 36, 221–263.
70. STOCKARD, C. R. *The physical basis of personality.* New York: Norton, 1931.
71. THOMPSON, D. W. *On growth and form.* Cambridge: Univ. Press, 1942.
72. THURSTONE, L. L. The stimulus-response fallacy. PSYCHOL. REV., 1923, 30, 354–369.
73. ——. *The nature of intelligence.* New York: Harcourt-Brace, 1927.

74. WEISS, P. *Principles of development.* New York: Holt, 1939.
75. WHITEHEAD, A. N. *Adventures of ideas.* New York: Macmillan, 1932.
76. ——. *Process and reality.* New York: Macmillan, 1936.
77. WHEELER, R. H. *The science of psychology.* New York: Crowell, 1939.
78. WINDLE, W. F. *Physiology of the fetus: origin and extent of function in prenatal life.* Philadelphia: Saunders, 1940.
79. WOODGER, J. H. *Biological principles.* London: Kegan Paul, 1929.
80. YERKES, R. M. Concerning the genetic relations of types of action. *J. comp. Neurol.,* 1905, **15**, 132–137.
81. ——. Animal psychology and the criteria of the psychic. *J. Philos., Psychol., & Scient. Meth.,* 1905a, **2**, 141–149.
82. ——. Psychology and defense. Symposium on recent developments in psychology. *Proc. Amer. Philos. Soc.,* 1941, **84**, No. 4, 515–542.
83. YOUNG, P. T. *Motivation of behavior.* New York: Wiley, 1936.